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THE GOVERNANCE OF DIGITAL CONTACT TRACING: THE ROLE OF STATES, CORPORATIONS, AND USERS IN THE DEVELOPMENT OF A DIGITAL STRATEGY AGAINST COVID-19 IN EUROPE

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Index

Introduction

On 31 December 2019, the Wuhan Municipal Health Commission announced the presence of cases of "viral pneumonia" (World Health Organization, 2020b). After more than three years, at the beginning of January 2023, the number of registered cases at the global level of that "viral pneumonia" has been 657,977,736, with 6,681,433 deaths (World Health Organization, 2023).
A few months after the first cases, on March 2020, the World Health Organization's (WHO) Director-General announced that the viral disease, which was discovered to be caused by the SARS-CoV-2, gained the status of "pandemic", since then called the COVID-19 pandemic. The WHO Director-General named the COVID-19 pandemic "not just a public health crisis", but a "crisis that will touch every sector" (World Health Organization, 2020c). Indeed, since the very first outbreaks, many domains have been directly or indirectly affected by the virus, especially due to the interventions aimed at containing its spread.

Of course, the global economy has been largely hit, with many countries expected to fall into recession in 2020, and per capita income contracting 7% in advanced economies and 2.5% in developing ones (World Bank, 2020). Several sectors from agriculture to the manufacturing industry, from finance to the sports industry, tourism, and aviation, have been affected by losses and contractions (Nicola et al., 2020).
Lockdowns and closures, among the main interventions against the virus, impacted the social and psychological lives of several individuals worldwide. In the UK, the National Domestic Abuse Helpline registered an increase of 25% in calls requesting help during the first period of the lockdown (Kelly & Morgan, 2020). A survey also showed how the pandemic caused anxiety, depression, and stress in people, with half the respondents stating that the outbreak hit them psychologically (Odriozola-González et al., 2020).
Another domain that has been impacted by the lockdowns caused by the pandemic, with significantly different outcomes, has been the natural environment. It has been shown that air quality, water quality, pollution, and wildlife benefited from the sudden interruption of industrial activities, international trade, road traffic, and tourism (Lokhandwala & Gautam, 2020).
Among those spheres that were somehow positively affected by this situation, technology, especially digital ones, registered significant improvements in several ways. Due to lockdowns and restrictions, a large portion of social interactions moved online, therefore online services grew quickly and consistently. The case of the video call software Zoom could work as an example. The company owning the software saw its revenues grow by 355% in the second quarter of 2020 compared to the revenues of the previous year. Furthermore, Zoom's customer base increased by 458% (Lambert, 2020).

These are just a few examples of the several ones that could be provided to argue that the COVID-19 pandemic should be considered, in Mauss's terms, a "total social fact", namely an event impacting every

aspect of society (Alteri et al., 2021).

Obviously, such a broad fact cannot be tackled as a whole in this kind of contribution. Therefore, a specific element of the "total social fact" has been selected as the topic of interest of this research.

1. The fight against the virus and digital contact tracing

It was well-known, even before the COVID-19 pandemic, that a pandemic cannot be contrasted just with vaccines and antivirals, namely pharmaceutical interventions. Pharmaceutical interventions usually take time to be properly developed and produced, that is why, especially in the early phases of the disease outbreak, non-pharmaceutical interventions (NPIs) are deployed (Aledort et al., 2007). With respect to COVID-19, many NPIs have been used by several countries since March 2020, such as face masks, hands cleaning products, curfews, closures, and lockdowns (Bo et al., 2021). Contact tracing is another standard NPI for infectious disease outbreaks that was also activated during the coronavirus pandemic (O'Neil, 2020). As the World Health Organization (2020a) points out, being able to know the contacts that an infected individual has had could help break the chain of transmission of the virus, thanks to following quarantine and isolation. The WHO clearly indicates the procedure that should be followed for contact tracing: "the contact tracing team should develop a list of persons who had been in contact with the COVID-19 patient. Each contact should first be contacted by phone or in person to determine whether they meet the contact definition and thus require monitoring" (ibidem, p. 3), moreover, the contact tracing team should monitor daily potential symptoms, calling or visiting those that have been isolated.

Such a procedure, called manual contact tracing, was quickly proved too slow to tackle the very fast diffusion of SARS-CoV-2. Furthermore, it suffered from another weakness, namely that it is hard for people to recall all the close contacts that they have had, usually in the previous 14 days, especially the shorter ones and the ones with people outside the family and friends relationships (Ferretti et al., 2020).

To circumvent these issues, a group of scholars, led by Luca Ferretti of the Big Data Institute in Oxford, published an article that showed how carrying out the contact tracing procedure through digital technologies could help bring the pandemic under control (Ferretti et al., 2020).

How contact tracing through digital technologies works will be attentively considered throughout the contribution, but some of its main features are worth anticipating. The idea of enhancing contact tracing through digital technologies has been around for more than a decade (Anglemyer et al., 2020), more specifically, Ferretti and colleagues suggested carrying out digital contact tracing (DCT) through smartphone apps. Smartphone owners should download contact tracing apps (CTAs) on their devices, which through Bluetooth, would measure the distance and time of exposure of contacts between people. When a person is diagnosed positive for the coronavirus, the app would warn about the risky encounter the people that were registered in the previous days within a certain reach and for a certain amount of time. The user that received

the warning should then get in touch with the general practitioner, discuss the case, and eventually quarantine (Ferretti et al., 2020).

Around March and June 2020, many CTAs have been designed, implemented, and released for public use in several countries (O'Neil, 2020). As experts who worked on these projects explained in interviews realized for this research, a DCT strategy was implemented through CTA in an extremely quick fashion, reducing the development period of such technologies from several months down to a few weeks. Such a compressed process is a privileged setting to observe the development of policies through digital technologies aimed at tackling the biological problem of the pandemic. The idea of applying digital technologies in the fight against a virus is of large interest and the design, implementation, and use of such technologies are worth exploring. Furthermore, the study of the development of DCT, focusing on its different phases, elements, and actors involved works as a relevant case study to observe the development of policies through digital technologies from a more general point of view.

2. The present contribution: theoretical framework, methodology, empirical enquiry

The following pages will further elaborate on the intersection between policy and technology with respect to DCT. For the moment it would be enough to say that both are relevant dimensions, but the latter for sure characterize more the issue of interest compared to the former one. Therefore, this work mainly relies on a heterogeneous social science scholarly tradition that has been reflecting on the issue of technology at least for the past 40 years. The so-called Science and Technology Studies (STS) scholarship, as it will be shown, offers a clear paradigm, relevant theories, and useful methodological suggestions to structure a solid research project. Within this broad tradition, two streams of contributions worked as the main reference. The Social Construction of Technology (SCOT) and the Actor-Network Theory (ANT). The first one, in its later configuration, offers flexible and useful concepts to interpret and read the development of new technologies. The second one, among other things, provides other valuable suggestions on the role of different types of actors involved in socio-technical processes. These two scholarships will be presented accordingly to the aims and interests of this contribution in chapter one, also stressing additional similar streams of literature and recalling the origins of the broad STS discipline, in which useful methodological suggestions lie as well.

The SCOT and ANT tenet of "follow the actor" (Baron & Gomez, 2016; Bijker & Law, 1992), namely considering and valuing the actors involved in socio-technical processes, worked as a strong methodological indication for this contribution. Since the goal was to focus on the development of DCT in Europe, three EU countries have been selected, based on relevant characteristics, to conduct three case studies. Within each national context, namely Italy, France, and Germany, relevant actors who participated in the development of national CTAs have been interviewed. Furthermore, official documents have been analyzed to better structure some of the dimensions of the issue of interest that could not be fully covered in the interviews, and to better

structure that empirical inquiry as well. Finally, to have a comprehensive, yet quite specific, understanding of a relevant actor's perspective, users' reviews have been analyzed. The users of CTAs are a core element in the whole DCT strategy, by scraping from the digital stores more than a hundred thousand reviews posted by users, and analyzing them through automatic and manual techniques, it was possible to grasp relevant information on how users engaged with these technologies. This last technique is a less known and used one, which could be considered part of the large digital methods family (Caliandro & Gandini, 2019). It will be properly addressed in the chapter dedicated to the methodology, that is chapter number three, as well as all the other related methodological matters.

In general, all the stances, approaches, and techniques described over there, are oriented toward understanding how DCT was implemented through CTAs in Europe, and why it resulted in a marginal non-pharmaceutical intervention in the fight against COVID-19. As it is easy to imagine, the methodology used in this contribution is not suited for measuring the impact of DCT as an NPI against the coronavirus pandemic. However, as it will be shown, many voices stated that DCT did not deliver on the promise that it seemed to make about getting the pandemic under control. Moving from this evaluation, as said, this contribution aims at studying what could have contributed to not making DCT raise to initial expectations. The main place where answers to this question are researched is the process of development of CTAs in the three analyzed countries and the EU.

The issue of DCT's development touches on several interesting points that characterize digital technologies in general. Chapter two will present three of them, presenting also relevant social science scholarly contributions on these topics. The research on technology governance, the role of firms, platforms, and infrastructures in the *datafied* world, and the issue of privacy offers valuable suggestions in reading the complex socio-technical phenomenon of DCT development. By building on works on these issues, this contribution aims, through its empirical inquiry, to offer some additional suggestions to better understand them, as the last chapter will show.

The empirical inquiry restitution starts with the analysis of some elements of DCT development that happened at the EU and global level since March 2020. Chapter four, precisely describes how DCT through CTAs works, focusing on some of its technical details that hide many relevant social dimensions. Then, the analysis of design, implementation, and use at the supra-national level is covered, considering how the academic debate developed on these topics, the involvement of national public institutions, and the contribution by Apple and Google. This chapter also addresses the role of Bluetooth and how its affordances impacted some relevant DCT characteristics. Moreover, the impact of other non-human actants is attentively covered, before closing the chapter with a brief overview of how DCT has been deployed in other countries outside Europe.

Chapter five opens the three chapters dedicated to the case studies analysis. This chapter is dedicated to the analysis of the Italian DCT strategy through the app Immuni. As it will be precisely justified, this case is the main one in the whole analysis due to some changes that happened during the data-gathering process. The structure for this chapter, and the following two, is based on the analysis of the three phases of Immuni's development. Initially, a deep analysis of the design process of the app is provided, focusing on official documentation and the gathered interviews. The role of actors related to national public institutions is particularly relevant in this phase and it is attentively explored. As it will be argued, the implementation phase does not have many nuances that need to be explored, while the use one has been tackled in quite an extensive fashion. The already mentioned, user reviews have been considered three times with three different foci. An initial one focused on descriptive metrics useful to have a general picture of when users posted reviews to the app and how they rated it. The second focus, zooming in a little more on the data, considered the most recurrent elements in the whole corpus of more than twenty thousand Italian reviews to grasp what were the main topics tackled by users when reviewing the app. Finally, the third step focused on a part of the large database, analyzing the 100 most-liked reviews, to really dive into the opinions, reported behaviors, and considerations that users had while using the app.
The chapter will close with a summarization of the whole Italia DCT's development process, trying to picture initial answers to the two research questions, which could be properly tackled only after the two following chapters.

The structure of chapter six on the French DCT strategy and the structure of chapter seven on the German one are very similar to the one of the analysis of Immuni. The empirical materials on the French and German cases are a little less rich than the Italian ones, therefore the analysis is a little less wide and deep compared to the previous one. Nevertheless, relevant findings emerge in both cases, stressing several dimensions of the design, implementation, and use processes of DCT through CTAs.

Approaching the final steps of the work, chapter 8 merges the findings of all three chapters based on the national case studies and draws comparisons between the three. Answers to the research questions are here more comprehensively presented. First of all, the first research question is tackled by attentively focusing on the different actors involved. Then, the main reason why DCT did not work in Europe is identified in the problematic relationships between different actors, which have been called "shakes" throughout the work.

Finally, chapter 9 concludes the work. After having briefly summarized the different steps of the contribution, this final chapter focuses on more general contributions that emerge from the whole analysis. More specifically, this work suggests a reconfiguration of the role of digital platforms, the relationship between the healthcare and the digital domain, and the concept of privacy. Furthermore, chapter 9 highlights some of the pros of the methodological strategy employed for this contribution, stressing the advantages of having a mix

of research techniques when dealing with a similar matter of research. Moreover, based on the findings of the analysis, policy suggestions are presented.

The analysis of the development of DCT through CTAs is a relevant issue of research in itself because it could help grasp one dimension of the total social fact of the COVID-19 pandemic. However, as anticipated, it could also be an informative study on some of the dynamics of present times, especially related to the development of digital technologies. Among the many findings and different dimensions stressed, the following pages will show that, when implementing a policy through digital technologies, the different actors involved play a key role in shaping the trajectories of the developed element, which means that - even more when dealing with public interventions - an eye should be kept on those who cannot participate in this process.

Chapter 1 – The theoretical framework for the analysis

1. Science and Technology Studies

1.1 The origin of the discipline

Even with its own internal differences, nowadays Science and Technology Studies (STS) is a quite identifiable and defined discipline (Jasanoff, 2017), but it has not always been like this. Indeed, STS was born from the mutual contamination of several scholarships that reflected on the role of science and technology within society.

In the mid-sixties, contributions from the fields of history, philosophy, sociology, anthropology, economics, and political and legal science started to converge towards what would have become a new discipline (Edge, 1995; Sismondo, 2010). Even within these broad and heterogeneous origins, scholars that have been reflecting on the precursors of STS agree especially on one element. A consistent part of this field of study builds on the work conducted by Thomas S. Kuhn (Hackett et al., 2008; Jasanoff et al., 1995; Rohracher, 2015; Sismondo, 2010).

In 1962, Kuhn published the first edition of "The Structure of Scientific Revolutions" (Kuhn, 1970). Through the years, it became a pivotal contribution in the field of philosophy of science, that helped change the perspective on the way science was perceived and studied (Hoyningen-Huene & Lohse, 2015; Sismondo, 2010). Among the many concepts, Kuhn introduced the idea that science develops through controversies and opposition between groups of experts that carry on different perspectives on a specific matter. When and whether the lack of consensus comes to an end, the considered science discipline reaches its maturity, entering the "normal" status and sharing a common paradigm. The paradigm, which is a defined set of theories and methods, gives normal science the look of a puzzle to solve (Kuhn, 1970). This analogy is related to the fact that, in Kuhn's eyes, normal science and puzzles, like crosswords or chess problems, share some pivotal features. First of all, they have regulations that limit problem solutions; then, they tackle solvable problems, and they lack the intention to change the regulations, neither want to test them; finally, they both rely on individual motivation of solvers/scientists to prove themselves expert in the field by solving the problems (Hoyningen-Huene & Lohse, 2015).

This new idea of science's evolution, which is not cumulative and linear, but relies on a larger role of scientists, and their need to cope with political, economic, and social constraints (Rohracher, 2015), was among the main takeaways that STS scholars got from Kuhn's scholarship. Of course, the legacy of the physicist, and then philosopher, is much larger. He also reflected on epistemological matters of researching, he confronted himself with philosophers of his time, like Popper, and he offered a more articulated reflection on science with respect to what STS scholars decided to build on (Hoyningen-Huene & Lohse, 2015; Sismondo, 2010).

Kuhn's work generated a first stream of contributions, which later converged in the field of STS and mainly engaged with the nature and practices of science and technology. Different foci emerged in this thrust as well, moving from the sociology of scientific knowledge, to actor-network theory (ANT), and approaches more interested in the meanings that people attach to science and technologies (Jasanoff, 2017). From this tradition emerged the works that most recently contributed to developing the science and technology studies' scholarship most consistently.

The seeds of STS can be also found in the scholarship of Robert K. Merton, who is largely considered the father of the social studies of science (Bucchi, 2002). In "The Sociology of Science: Theoretical and Empirical Investigations", Merton underlines the need to study the interplay between science, society, and culture (Merton, 1973). In his works, he emphasized the role of socio-cultural factors when analyzing scientific practice, questioning its deterministic tie with economic development, and considering science as part of a larger social system (Bucchi, 2002; Rohracher, 2015). His scholarship, however, remained strongly related to positivistic views of science and analyzed it as a singular broad element, without considering science's internal differences and nuances (Jasanoff et al., 1995; Sismondo, 2010). Nevertheless, the idea that science has a social structure that builds on an ethos, namely norms of behavior for guiding scientific practice, introduced some concepts that would be later developed by STS researchers (Sismondo, 2010). Merton's noticed how science is largely based on communities of experts and related subcultures that shape a normative order, often sustained and supported by reward systems (Rohracher, 2015).

Another strand of scholarships that later entered STS can be identified in the contributions interested in the impacts and risks of science and technology on human life. This approach developed quite rapidly in the late 1960s in the US academic world with several university programs. These programs were often founded and directed by scientists and engineers concerned with the social implications of innovations in their fields. However, in a little more than a decade, this approach lost its strength. The main reasons could be found in the lack of integration with other social science disciplines, and the absence of a strong theoretical stance since most of the contributions were mainly related to case studies relevant for the time, which made some works look like journalistic contributions (Jasanoff, 2017).
Scholars interested in the social impact of technology had as one of their main tenets the idea that changes in social structure and technology development are interdependent. Within this tradition, Lewis Mumford and Jacques Ellul are the most representative scholars (Rohracher, 2015).

It is no easy task to clearly identify all the elements and scholarships that contributed to shaping STS, neither it is the aim of this section of the work. However, it could be useful to point out some additional traditions that contributed to constructing this field of study. In the 1960s, starting from England, and then spreading at the worldwide level, debates on the relation of science with economy and technology started to emerge, stressing the importance of better understanding how the investments in research could generate value. The

main idea was to develop scientific knowledge on science, to do "science on science", predominantly for policy purposes, and to better decide how to allocate resources for research disciplines. Throughout the years, these debates also evolved in a quantitative approach to scientific knowledge measurement, like bibliometrics, that partially holds a spot in present science and technology studies (Jasanoff et al., 1995).

In the late seventies and early eighties, the science and technology studies field finally started to emerge, but there was not much integration between studies covering the two issues (Pinch & Bijker, 1984). Initially, the "science side" was still largely predominant (Rohracher, 2015). In the UK, "the sociology of scientific knowledge" developed, dealing "precisely with what comes to count as scientific knowledge and how it comes so to count" (Collins, 1983, p. 267). Scholars started to study the scientific method, and the scientific debates and controversies (Collins, 1983; Rohracher, 2015). Largely building on Kuhn's legacy, David Bloor and Barry Barnes shaped the "strong program" in the field of sociology of scientific knowledge. Their main tenet was that scientific knowledge must be explained through naturalist patterns, refusing to rely on the idea that truth and rationality can mechanically attract disinterested science, as suggested by traditional history and philosophy of science. These traditional disciplines assumed that sociology needed to focus just on the failure and errors of scientific knowledge, a conclusion that the two authors strongly rejected, in favor of an approach focused on the construction of such knowledge (Hackett et al., 2008).

Always focusing on scientific controversies, the empirical program of relativism (EPOR) mainly analyzed how scientific facts emerged, developed, and were shaped by the interplay of groups of scientists (Rohracher, 2015). EPOR has shown how scientific knowledge is empirically constructed. It introduced concepts that later largely influenced the study of the social construction of technology. Within this strand, the concept of interpretative flexibility was developed, namely the idea that scientific findings are open to more than one interpretation. Moreover, EPOR elaborated on the development of scientific knowledge through reaching consensus and the closure of debates among scientists (Pinch & Bijker, 1984).

Ethnography contributed to enriching the sociology of scientific knowledge as well. Some scholars decided to study by direct observation how scientific facts and knowledge are constructed, leaving the perspective limited just to scientific debates and controversies behind (Knorr-Cetina, 1983). One of the most influential contributions in the field is Bruno Latour and Steve Woolgar's book (1979), whose title largely tells about the ethnographers approach to the field of scientific knowledge: "Laboratory Life: The Construction of Scientific Facts". Scholars studying laboratories had the chance to obverse how scientific knowledge largely relies on the scientists' skills and culture (Collins, 1983; Hackett et al., 2008; Knorr-Cetina, 1983).

In the emerging field of STS, in the 1980s happened the so-called "turn to technology", since many researchers started to focus on the analysis of technology (Woolgar, 1991). New labels were used in trying to define what appeared as new disciplines, or at least as new branches of the sociology of scientific knowledge: Social Shaping of Technology (R. Williams & Edge, 1996), Social Study of Technology (Woolgar,

1991), both identified with the acronym SST. Authors like Trevor J. Pinch and Wiebe E. Bijker (1984) introduced the analysis of technological artifacts, building on the work that had been done on science facts. The two authors clearly aimed at bridging the gap between a constructivist perspective in the sociology of science, which was more advanced thanks to EPOR's contributions, and the same perspective in the sociology of technology that still needed to be fully developed (*ibidem*).
Despite the different denominations, the contributions of the authors that followed the "turn to technology" can be fully considered as part of the STS discipline, which since then began appearing as more clearly defined (Hackett et al., 2008). Thereafter, other scholars started doing research on the interplay between technology and society, building on the strong belief that deterministic approaches to technology must be avoided (Mackenzie & Wajcman, 1999; Russell & Williams, 2002).

The STS discipline gained its own strength across the 1990s. Its introduction in academic programs of relevant universities in the United States, such as Carnegie Mellon, Cornell, Harvard, and MIT, contributed to STS's establishment. In Europe, STS programs were circulating since the seventies, but also thanks to the support that the European Union provided around the end of the century, the research networks developed especially in the Netherlands, Scandinavia, Switzerland, United Kingdom (Jasanoff, 2017).

The origins of science and technology studies are heterogeneous and complex. A brief overview of them has been presented, but it is relevant for the work to deeply focus on some of the contributions from this discipline to support the research aims. Since this work studies technological elements, the STS's scholarships specifically dealing with technology are now considered to define a proper, articulated, and useful theoretical toolkit for the next steps of the study.

1.2 The feminist perspective and the systems approach to technology

Before diving into the two main STS strands that provide useful concepts and guidelines for this analysis, it is worth mentioning two additional schools of thought in this field. They are not going to be deeply considered since they do not match the issues of this work, but it is important to be aware of these traditions, also to have a more complete overview of the STS scholarship.
When describing the different approaches to the study of science and technology, scholars acknowledge the significant impact of the feminist perspective (Lagesen, 2015; Oudshoorn & Pinch, 2003; Sismondo, 2010; Wilkie, 2010). This tradition has been developing since the 1970s, clearly stating that the construction of technology is also a matter of gender relations (Wajcman, 2000). The first evidence that emerges from the studies in this field, which have been growing in number through the years, is that women are underrepresented in the design, production, and consumption of technology: they are somehow excluded (Lagesen, 2015; Wilkie, 2010). More recent scholarships have also pointed out how gender is an important driver in the process of construction of technology, introducing the idea of co-construction, while the latest developments focus on the inclusion of women in ICTs, developing the perspective of cyberfeminism

(Lagesen, 2015). Anyway, all the different approaches to technology that stress the importance of including a gender perspective move from some of the ideas introduced with the social construction of technology (SCOT) school of thought.

With respect to the system approach, some authors suggested that it could be considered part of a broad definition of the social construction of technology perspective as well (Bijker et al., 1987). The main contributor in the system approach is Thomas P. Hughes, who largely built his work on principles from the history of technology discipline (Law, 1989). Pinch and Bijker (1984), reflecting on a sociological approach to the study of technology, considered the history of technology discipline as too limited. In the eyes of the two scholars, this approach was too descriptive, and it didn't focus on failing technological artifacts. Instead, Pinch and Bijker recognized that Hughes's concept of "technological system" was promising for a sociological reflection on technology (*ibidem*).

Technological systems can be considered as heterogeneous and complex groupings of components, such as physical artifacts, organizations, and legislative artifacts (Hughes, 1989). Moreover, in the system approach, technology shaping is not just a matter of technological artifact's construction, but it also incorporates potential intervention on related social, economic, political, and scientific factors; therefore, innovators should be considered as system builders, since their goal is to intervene on larger scale, and not just the artifact's one (Law, 1989). From the analytical point of view, the system approach stresses the importance of focusing also on the setting in which technology is situated, paying attention to its relationship with other elements, such as institutions (Bijker et al., 1987).

1.3 The SCOT perspective

The social construction of technology approach originated around the mid-eighties as a perspective that firmly opposed technological determinism (Bijker, 2010, 2015; Russell & Williams, 2002).

Technological determinism claims that technology develops autonomously outside society, without being influenced by social, economic, and political elements, but it can greatly influence social change (Bijker, 2015; Wyatt, 2008). Moreover, it fosters the idea that technology is a sort of black box, not influenced by any other external actor, or within which there is no chance to "look" to conduct a critical analysis on socio-economic patterns behind it (Prell, 2009; R. Williams & Edge, 1996). SCOT scholars decided to show the fallacies of technological determinism by analyzing how artifacts are indeed largely dependent on social elements. They deliberatively choose to focus on the very physical component within the broader domain of technology, also to question the technological determinism's research strategy, based on a flat and linear view of technological development (Bijker, 2015). The safety bicycle was the first artifact that was analyzed by Pinch and Bijker to first introduce the main concepts of SCOT and show how, even artifacts, whose invention was considered linear, reached present configurations through social shaping (Pinch & Bijker, 1984). Through the

years, scholars have then applied SCOT principles to the study of the most different artifacts, such as missiles (MacKenzie, 2012), plastic (Bijker et al., 1987), and the synthesizer (Pinch, 2009).

1.3.1 The construction of the bicycle as presented by Bijker and Pinch

In a conference in the Netherlands in 1984, Pinch and Bijker presented their study of the social construction of the safety bike (Bijker et al., 1987; Pinch & Bijker, 1984), which has been described also in a later work (Bijker, 1996). As previously mentioned, the authors moved from the idea that considering the evolution of technological artifacts through linear models, as done in innovation studies or history of technology, is a largely biased approach. Conversely, they employed a multi-directional model that permits to focus also on failed artifacts, which could help to better understand how the successful ones came to be preferred and used (Pinch & Bijker, 1984).

The history of the bike dates back to the time of Leonardo da Vinci (Bijker, 1996), but the two scholars paid more attention to the different bike models and configurations that emerge from the 1880s onwards (Bijker et al., 1987).

The "Ordinary" high-wheeled bike, later known as "Penny-farthing", evolved in many other models, such as the "Xtraordinary", the "Club Safety", the "Geared facile", due to contributions of several relevant groups that proposed and applied innovations to the original model, following own necessities and desires. Among these relevant groups, the authors account producers and users of the artifact, but also those who opposed the use of the bicycle (e.g.: "anti-cyclists").

Originally, the most represented user group of the "Ordinary" was mainly composed of young men that utilized the bike as sports gear, since quite demanding physical effort and skills were required for utilizing it. In the beginning, the non-user group was significantly larger than the users one, either because many people could not afford the artifact or because they were not physically capable of utilizing it. There were also those who opposed the use of the "Ordinary", and even some restrictions were introduced to the bicycle road use. Women were among those excluded from the use of the high-wheeled, for many reasons: physical strength, safety, decency. However, also thanks to women cyclists the "Ordinary" evolved. Other non-users contributed to the evolution of the bicycle as well, especially because they stressed safety reasons since accidents involving "Ordinary" riders happen quite frequently.

Safety could be considered one of the main problems that pushed manufacturers and invertors to try innovating high-wheel bicycles. In the later years, three main new models were developed: the tricycle, which made bike riding more accessible also to less athletic people; the "Safety Ordinary", which was basically a high-wheeled bike with structural changes towards increased safety of the rider; new low-wheel designs, like the "Bicyclette", "The Rover", and the "Dwarf Safety Roadster" that manly changed the size of the wheels. Further problems with the evolving bikes emerged, vibration was one of these. It is interesting to consider how this was not a problem for users of the "Ordinary" as a sports gear, while vibrations were a significant

issue to potential users of the low-wheeled bicycle.

Around the 1890s, the air tire started to be introduced on bicycles, applying an innovation that was proposed around forty years earlier for horse carriages with limited success. The innovation not only contributed to reducing vibration, but it also increased performances of the bikes, therefore air tires later become appreciated also by sport riders that initially refused them.

The change in design and the introduction of the air tires, progressively made the safety bicycle emerge. The "Ordinary", which started to be called "Penny-farthing", declined, not without the active opposition by some passionate old-style high-wheel riders. Of course, the design and the components of the safety bicycle continued to evolve through the years: the chain drive was slowly introduced, the frame was reshaped many times, and the brakes changed as well. The safety bicycle reached stabilization, and its diffusion in the UK was supported also by a Parliament act that entitled them to a place on the roads, since they could be considered a carriage. Many more people and social groups became users of the artifact, the bicycle was no more something exclusively utilized by rich athletic people, and a whole new industry developed (Bijker, 1996).

1.3.2 Critics to early SCOT approach

Some scholars moved a set of critics to the idea of the social construction of technology as initially formulated by Bijker and Pinch in their study of the bicycle (1984). First of all, scholars criticized how the concept of "relevant social group" has been employed, since the two authors considered it as the association of "all members of a certain group who share the same set of meanings attached to a specific artifact" (Humphreys, 2005, p. 233). It has been stressed how Bijker and Pinch did not pay enough attention to the actors involved in the process of technology's definition since the two scholars did not include in their analysis less relevant groups and did not consider the relationships between different groups (Clayton, 2002; Humphreys, 2005; Russel, 1986).

Furthermore, some scholars also criticized the absence of the idea of a social structure, a wider context, or a milieu around the actors and the relevant social groups, which could influence the way they shape the technology (H. K. Klein & Kleinman, 2002; Russel, 1986). By analyzing the development process of mountain bikes, a very similar case to the one analyzed by Bijker and Pinch (1986), Paul Rosen (1993) showed how the changes in the bicycles' design bear close relations to what was happening in the wider context, and they were not just influenced and guided by the relevant social groups' values and strategies.

To this set of critics, the two fathers of the SCOT provided detailed answers and further argumentations (Bijker & Pinch, 2002; Pinch & Bijker, 1986). The two authors pointed out how they were aware of the fact that the context plays a key role within the technology's definition process, and that the involved relevant social groups are quite numerous and diverse. However, with respect to their analysis of the bicycle, they considered the approach acceptable, since "all forms of sociological explanation in which groups or structures

are identified can never be adequate in the sense that all groups and structures are themselves embedded within an endless web of other groups and structures. Spelling out all such contexts is clearly impossible. All that can be attempted is to spell out sufficient context for the purposes at hand"(Pinch & Bijker, 1986, p. 353).

1.3.3 Later developments of SCOT

The debate that raised around the first formulation of Bijker and Pinch perspective contributed to transforming SCOT and pushing its boundaries to the point that the two authors in later contributions recognized a distinction between a "broad" or "mild" perspective of the social construction of technology, and a "narrow" or "radical" one (Bijker, 2010, 2015; Pinch, 2009). The narrow one is strictly related to the concepts presented with the case study on the safety bicycle. On the other hand, SCOT assigns a larger role to the influence of the social context in the development of technologies, embracing many different elements and perspectives, even the actor-network theory by Callon, Latour, and Law that will be later presented (Bijker, 2010, 2015).

Building on its first configuration from the case study on the safety bicycle, but gathering suggestions along the way, through the years SCOT defined useful theoretical concepts for the study of technology. First of all, the concept of relevant social groups is of utmost importance. Technology needs to be described "through the eyes of relevant social groups" (Bijker, 2010), which are groups of people, institutions, or organizations that share common meanings and perspectives on artifacts (Pinch & Bijker, 1984). From a methodological point of view, Bijker and Law (1992) suggest that the identification of relevant social groups when analyzing technology is largely based on the intuition of the research, who could rely on the principle of "following the actors" to define a proper research strategy.

Strictly connected to the concept of relevant social groups, SCOT incorporated the one of interpretative flexibility. As previously mentioned, this concept comes from the EPOR tradition, where it indicated how different interpretations of nature are available to scientists. Conversely, in SCOT interpretative flexibility means that many interpretations of the same technology are produced by the different relevant social groups (Bijker et al., 1987). Coming back to the safety bicycle example, interpretative flexibility made the Ordinary bike perceived as the "unsafe" bike by some people or as the "macho" bike by others (Pinch, 2009). The relationship between different social groups' perspectives results in the so call technological frame (Linderoth & Pellegrino, 2005). It is a concept that builds on the studies on science as well since it is similar to Kuhn's idea of paradigm (Bijker, 2010). Technological frames are common interpretations of technology that have developed among people within a group and become shared knowledge (Orlikowski & Gash, 1993). Technological frames, once defined, could evolve, always based on the interpretative flexibility of relevant groups (Linderoth & Pellegrino, 2005).

Interpretative flexibility among groups tends to reduce over time, the problems and the discrepancies on a

certain technology begin to fade, and the stabilization of the technology is reached (Rosen, 1993). Closure and stabilization are two additional central concepts within the SCOT's theoretical framework, they indicate the final steps of the social construction of an artifact, where different perspectives from the actors converge towards a commonly shared artifact, whose interpretation does not present too many significant differences (Bijker, 2010). Bijker and Pinch (2002) stressed how stabilization could be a long process, that, in the case of the safety bicycle, took many years. They explained how it is quite complicated, and probably even useless, to clearly try reconstructing the exact amount of time that took for an artifact to go through stabilization and reach closure.

Another transformation that has undergone the SCOT scholarship is related to its unit of analysis. The initial approach was mainly interested in describing the process of social construction of singular artifacts. As previously mentioned, the focus on artifacts was oriented towards a straightforward critique of technological determinism. Next to this approach, SCOT scholars started to focus on technological systems, namely the artifact along with the social, organizational, economic, and political elements around it. Further developments happened with the introduction of the sociotechnical ensemble as a unit of analysis. Focusing also on this unit contributed to broadening the range of approaches in SCOT, stressing the importance of considering society and technology as highly connected and interdependent. Finally, SCOT introduced technological culture as an additional unit of analysis. This last evolution helped scholars analyze not only the shaping power that society has on technology but also the reshaping one that the latter has on the former (Bijker, 2010).

The additional units of analysis contributed to developing the previously-mentioned "mild" or "broad" approach to SCOT, which is considered to comprehend also the actor-network theory (ANT) (Bijker, 2015). However, ANT scholarship developed following a separate path and it introduced very relevant and useful concepts to the study of technology.

1.4 Actor-network theory

Actor-network theory (ANT) developed across the seventies and the eighties, emerging from a group of scholars affiliated with the Centre de Sociologie de l'Innovation at the École des Mines de Paris (Muniesa, 2015). The main authors that contributed to its initial definition were Bruno Latour, Michel Callon, and John Law. In the early works of these scholars could already been spotted the seeds of the later developed ANT, since their main focus was the heterogenous networks that emerge in the scientific field, namely ensembles of human actors, cultural elaborations, and unanimated objects (Rohracher, 2015).

Through the years ANT's scholars started studying technology, and progressively distanced themselves from radical constructivists approaches, claiming a role also for non-human actors within the process of technology development and the presence of technology within society (Baron & Gomez, 2016). In the eyes of ANT's authors human and non-human actors act together in the social domain, creating associations that define

networks (Krarup & Blok, 2011; Sismondo, 2010).

Bruno Latour has been showing through many case studies how non-human elements have agency. A well-known example is “the sleeping policeman”, a British expression for speed bumps. The French scholar meticulously describes the issue of cars traffic that his neighborhood is experiencing due to proximity to the crowded Cornell University. After some years of study and trials, the best solution to slow down traffic appeared to be speed bumps. Latour argues how drivers’ behaviors were modified through these non-human elements. Since drivers care about their cars and don’t want to damage them, they slow down when approaching the sleeping policeman, significantly reducing travel speed and decreasing the noises that bothered the neighborhood (Latour, 1992b). Another less known, but equally useful, example of non-human agency on human activities presented by the author is the one related to the heavy hotel’s keyholder. Once again Latour provides a detailed description of the issue, namely hotels’ clients losing the keys of their room because they carry them out in daily activities and do not leave them in the hall. The French scholar shows how, through the introduction of heavy keyholders, very uncomfortable to carry around, the number of people that left the keys in the hotel’s hall significantly increased, and the issues of losing rooms’ keys was solved (Latour, 1992a).

The concept of non-human agency has been widely used by scholars, even when studying more complex topics such as the construction of aircrafts (Law & Callon, 1992), or lighting systems in Africa (Akrich, 1992), and it has become one of the main tenets of the ANT tradition (Baron & Gomez, 2016; Sismondo, 2010). However, the principle of considering humans and non-human actors as symmetrical from both an ontological and methodological point of view is not unanimously shared. Scholars have been stressing how, despite it is important to consider non-human agency on human activities, the two actors maintain relevant differences (Baron & Gomez, 2016; Pinch, 2009; Sismondo, 2010). Nevertheless, one of the most significant theoretical contributions of the concept of non-human agency has been the introduction of the issue of materiality to the study of technology (Russell & Williams, 2002). Building on the concepts of affordances of artifacts and their shaping ability introduced by ANT scholars (Akrich & Latour, 1992; Latour, 1992a), later contributions deepened the concept of materiality, focusing on the physical matter of objects and the influence it has on users (Klenk & Duijf, 2020; Leonardi, 2010). Authors showed how even digital technology deals with materiality, both from a content point of view and from an infrastructural one, since they rely on real estate, energy, and the extractive industry (Pink et al., 2016). Furthermore, it has been noted that affordances are features also of digital artifacts such as apps and social media platforms (Bucher & Helmond, 2018).

The ANT tradition developed many other useful concepts to the study of technology. Among these, the concept of script is worth mentioning. Madeleine Akrich, another well-established scholar from École des Mines de Paris, suggested the idea of considering technology development as the process of defining movies

scripts (Wilkie, 2010). In the development of new technologies, innovators and designers define the script, inscribing their values, strategies and perspectives in technological artifacts, and they define and foresee future uses of their designed products as well (Akrich, 1992; Akrich & Latour, 1992). However – and this is another relevant element introduced with ANT – users may follow the script that designers provided to the artifact and play the role that they were assigned, or they may follow alternative scripts and engage with the artifact in ways that were not fully inscribed in it (Akrich, 1992). Later contributions have been working on the concept of users, showing how they can modify, resist, and reconfigure technologies (Oudshoorn & Pinch, 2003).

Some ANT concepts have been proved useful also for the analysis of elements of the digital domain. For instance, the design of digital systems has largely embraced the idea of designing the user experience. However, designers know how people's behavior is often unpredictable and hard to understand (Redström, 2006). Furthermore, when dealing with software architectures, the similarities with ANT concepts are also semantic, since developers act on the *scripts* of their products. Through coding, they are able to define the affordances of the software, based on their values and strategies (Lessig, 2009).

1.5 Further STS developments

While still conserving their specificities, the SCOT and ANT scholarships have come closer together within the broader discipline of STS. As presented above, through the years they developed a useful broad theoretical toolkit for studying technology in society, relying on a general principle that has been clearly expressed by Law and Bijker (1992): "technology is never purely technological: it is also social. The social is never purely social: it is also technological. This is something easy to say but difficult to work with. So much of our language and so many of our practices reflect a determined, culturally ingrained propensity to treat the two as if they were quite separate from one another" (ibidem, p. 305).

With the aim of analyzing technology and society, many more studies contributed to introducing new theoretical concepts to STS or widening the already existing ones. Authors reflected on the meanings connected to technology, both as inscribed within the artifacts through processes of sense giving by designers (Spicer, 2005), and as related to the surroundings of the artifacts, for instance through marketing (Carlson, 1992; Mackay & Gillespie, 1992). The study by W. Bernard Carlson (1992) on the failed wide diffusion of Edison's motion picture is an illustrative one.

Thomas A. Edison developed the motion picture around the end of the eighties of the XIX century. Through the years he progressed his technology and built a team of managers to organize the manufacturing and the selling of the machines, the production, and the diffusion of contents. Carlson provides a detailed report of the different steps that Edison's invention made through the years until its *de facto* failure just before the 1920s. In the scholar's eyes, the main reasons for such failure could be spotted in the frame of meanings that Edison applied to his invention. First of all, he refused to ease the access to motion pictures to the general

public, since he considered it a leisure good for the business class. Then, he and his managers decided to invest in educational films, missing once again the opportunity to reach the general public. In general, Edison and his personnel stuck to their own middle-class tastes and values, which made them make decisions that did not match the wider audience's taste, preventing Edison's motion picture solution from breakthrough. As a general takeaway of the study of Edison's motion picture's development, Carlson highlights that "inventors are not just bundles of technical solutions; they are also bundles of social solutions. Inventors succeed in a particular culture because they understand the values, institutional arrangements, and economic notions of that culture. Moreover, they are often willing and able not only to invent technological artifacts but also to modify the social and economic arrangements needed for that artifact to come into use" (Carlson, 1992, p. 175).

The context in which technology is developed and then used received increasing attention from scholars. It has been shown how the context of use is an additional relevant dimension that needs to be inscribed while developing artifacts and services to higher the chances of success in front of users (Heeks, 2005). Furthermore, it is the context itself that can shape technology development, as well as its use in later phases (Russell & Williams, 2002).

Another useful concept that emerged within the STS discipline, which has been widely used in many other studies is the one of boundary object (Sismondo, 2010). It was first introduced by Susan Leigh Star and James R. Griesemer in a 1989 article that reflected on the idea of cooperation in absence of consensus. The authors reflected on a tension that can be spotted in the scientific domain between elements that pull toward opposite directions. On the one end, science needs to come to generalizable and shared findings; on the other, the actors involved in it, namely scientists, researchers, professionals, etc., could have different perspectives on the same matter, and often conflicts might emerge. Therefore, it often happens that cooperative relationships in scientific research are developed without reaching full consensus on meanings attached to objects and methods, mainly because of interpretative flexibility. The authors stress that the progress of scientific knowledge requires a minimum common ground of shared meanings, which however does not need to reach full agreement on all the elements (Star & Griesemer, 1989).

The researchers build their argument by presenting the development of the Museum of Vertebrate Zoology (MVZ) at the University of California, Berkeley. The case study shows how different perspectives align toward a common element through boundary objects. The museum was founded in 1908 by Annie Montague Alexander, a passionate amateur naturalist, its main focus was preserving California's nature, gathering specimens of local flora and fauna. In the development of the museum took part scientists, collectors, the University of California, Berkeley, as well as the general public and trappers. Star and Griesemer thoroughly describe how the museum and its activities were significantly different in the eyes of the several members of these groups, following the well-known concept of interpretative flexibility. Despite the different

perspectives, the authors stress how all participants agreed on the aim of local plants and animals preservation. For some groups, such as amateurs collectors, trappers, and the general public this goal was enough to fulfill their interests. While for other groups, as for instance the scientists, it was just the first step towards greater professional aims. Throughout their analysis Star and Griesemer mention, besides the museum itself, other boundary objects that contributed to establishing cooperation between the several groups: the specimens of local flora and fauna, field notes, maps, and some others. Along with the analysis of the Museum of Vertebrate Zoology, Star and Griesemer provide a clear and detailed definition of boundary object:

> "Boundary objects are objects which are both plastic enough to adapt to local needs and the constraints of several parties employing them, yet robust enough to maintain a common identity across sites. They are weakly structured in common use, and become strongly structured in individual-site use. These objects may be abstract or concrete. They have different meanings in different social worlds but their structure is common enough to more than one world to make them recognizable, a means of translation. The creation and management boundary objects is a key process in developing and maintaining coherence across intersecting social worlds" (Star & Griesemer, 1989, p. 393).

Later studies built on this idea and expanded its reach (Sismondo, 2010). Authors applied it to abstract concepts as well, showing how these concepts can ease communication and understanding across disciplines, establishing a common ground between different actors (Baggio et al., 2015). It is one of the original authors that clarified how "object" does not necessarily indicate a concrete element, but something people can interact with, whose "materiality derives from action, not from a sense of prefabricated stuff or ''thing-ness" (Star, 2010, p. 603).

The fields in which the concept of boundary objects has been employed are numerous. It has been shown how fancy poultry and rabbits became boundary objects in the early XX century and how they brought different scientific disciplines closer together and facilitated relationship building with commercial actors (Marie, 2008). And again, scholars have analyzed how material elements such as drawings or memos, and less-defined factors that promote openness and trust play the role of boundary objects in contract negotiations. It often happens that negotiations may occur within a context of limited shared knowledge, reduced common ground, and opposing viewpoints. Within this scenario, the mentioned elements can help reach agreements and connect the two involved parties (Koskinen & Mäkinen, 2009). The concept of boundary objects has been proved useful to study also elements of the digital domain. It has been shown how software applications and digital tools can facilitate the sharing of knowledge between cross-cultural working teams (Barrett & Oborn, 2010).

As already said, this theoretical tool has been widely used in many fields, until the point of abusing it. That is

why Susan Leigh Star, in 2010, published an article to point out the actual characteristics of boundary objects, clearly stating that this concept should be employed carefully to prevent the risk of considering every element of social interaction as a boundary object (Star, 2010). Anyway, with this last caveat in mind, this concept can be a useful one when studying technology.

The STS tradition, especially the ANT's one, also contributed to developing a new perspective on the study of objects within sociology. Traditionally, the discipline was well-interested in considering the nature of objects and their social role: Marx's scholarship is the most prominent example. In the later approaches, the material dimension was left behind in favor of perspectives more focused on the role of culture. Especially with structuralism, semiotics, phenomenology, and symbolic interactionism, objects were considered mainly from the point of view of language and meanings attached to them, disregarding their materiality. Conversely, the most recent perspectives came back to the study of materiality, largely inspired also by the work carried out by the scholars who developed the actor-network theory approach (Engeström & Blackler, 2005).

The study of materiality and objects found breeding ground also in organization studies, where technology plays a pivotal role. Organizations' role in inscribing the many objects of the world has been thoroughly described, as well their material dimensions that add to the symbolic and political ones (Joerges & Czarniawska, 1998). The sociomateriality of organizations' practices has been strongly stated in this field of research bringing as an example the Google search engine. The Google search could be considered as both a social and material element since it "was produced and is maintained by software engineers, that executes on computers (configured with particular hardware and software elements), and whose operation depends on the millions of people who create and update web pages every day, and the millions of people who enter particular search terms into it" (Orlikowski, 2007, p. 1440).

2. The theoretical toolkit

The STS tradition can rely on almost forty years of studies and contributions which have roots in scholarships that were developed even some decades earlier. This chapter tried to provide a coherent and broad overview of this tradition. Despite most of the concepts that have been presented being an essential reference for the whole analysis, some pivotal elements are worth repeating to define more precisely the main theoretical toolkit for this work.

First of all, the SCOT corpus of studies offers essential guidelines with respect to the crucial issue of studying technology through the eyes of relevant social groups. The groups of people institutions, or organizations involved in the design, development, and use of a technology could have different perspectives on it, these differences need to be analyzed and precisely considered (Bijker, 2010). Furthermore, the SCOT tradition, in its early configuration, but mostly in its later one, paved the way for a better understanding of what the study of technology actually means. It is of course an issue of technological artifacts, but also an issue of social,

organizational, economic, and political elements around them, since – as already quoted above: “technology is never purely technological: it is also social. The social is never purely social: it is also technological” (Bijker & Law, 1992, p. 305).

Moreover, from the ANT tradition, the idea of non-human agency and the importance of materiality is of utmost importance. As it has been introduced and it is going to be better explained in the following pages, DCT also deals with material elements (e.g.: Bluetooth, mobile devices) that played a key role in the definition, development, and implementation of a tracing strategy to fight the coronavirus pandemic.

From the more recent developments of the STS field, the concept of boundary objects is a decisive one. Successful solutions are the one “plastic enough to adapt to local needs and the constraints of several parties employing them, yet robust enough to maintain a common identity across sites” (Star & Griesemer, 1989, p. 393), this research also aims to understand whether this is the case of digital contact tracing apps or not. The useful concepts from the STS tradition, succinctly synthesized in this brief theoretical toolkit, close the theoretical section and work as a bridge to the following pages where additional perspectives, more related to the issue of the study, are presented and thoroughly considered.

Chapter 2 - DCT as a complex socio-technical phenomenon

1. A complex phenomenon with many relevant connected issues

The complexity of the object of study, namely the design, implementation, and early use of digital contact tracing during COVID-19, and the teachings from the STS tradition on the socio-technical dimension of social phenomena open additional interesting scenarios that are worth considering.

This chapter presents reflections on three different issues that suggest relevant elements for this research, and to whom the research itself aims to contribute. First of all, technology governance is analyzed. The literature that focuses on this topic helps to understand that behind every type of technology - digital ones included - lies an articulated interrelation between public institutional actors, firms, civil society organizations, and final users. The latest developments in this field suggest that, when dealing with the Internet or digital technologies, the role of private firms is growing. The firms that nowadays play the most prominent role in this domain are tech firms, which have become infrastructural platforms. General characteristics of these kinds of actors are then analyzed, stressing – among the other elements – the centrality of data, which introduces the third and last issue. As a final step in constructing a more articulated frame for the analysis, studies that reflected on the concept of privacy are considered and the evolution that this concept underwent in recent times in different fields of study is described.

Of course, there are not just three sociologically relevant issues related to DCT, but the three that have been selected seem to be among the most interesting ones that offer the chance to dive into the socio-technical complexity of the phenomenon without getting lost in its many nuances.

In this regard, the second part of the chapter engages with the not-so-many contributions that analyze the socio-technical complexity of DCT. Moreover, an overview of the social science studies that have been focusing on this topic during the past three years is presented, highlighting contributions that considered the debate on the ethics of DCT, especially related to privacy, and studies that considered attitudes and behaviors towards it. Finally, the works on the more technical and epidemiological aspects of digital contact tracing are briefly considered.

1.1 Technology governance: who is in charge?

When considering technology, a key element is focusing on its governance. The Organization for Economic Co-operation and Development (OECD) provide a useful, complete, and significant definition of this matter:

> "Technology governance can be defined as the process of exercising political, economic and administrative authority in the development, diffusion and operation of technology in societies. It can consist of norms (e.g. regulations, standards, and customs), but can also be operationalized through physical and virtual architectures that manage risks and benefits.

> Technology governance pertains to formal government activities, but also to the activities of firms, civil society organizations and communities of practice. In its broadest sense, it represents the sum of the many ways in which individuals and organizations shape technology and how, conversely, technology shapes social order" (OECD, 2019).

In this definition, some of the ideas of the STS's tradition resonate, such as the role of different actors in shaping technology's characteristics, and the action of technology itself in shaping back the social order. First of all, this element is coherent with the theoretical framework that has been depicted in the previous chapter. Then, it is also in line with some contributions that more specifically consider information and communication technology's (ICT) governance, which also stressed significant touching points with the STS (Hofmann et al., 2017; Musiani, 2015; Ziewitz & Pentzold, 2014), especially with respect to the need of focusing on the relation and mutual influence between technology and social practice (Flyverbom, 2016). However, identifying a proper definition of ICT governance is quite difficult because most of the contributions are often influenced by ideological standpoints (Musiani, 2015; Ziewitz & Pentzold, 2014) and the concept is usually pictured in a quite fuzzy and inconsistent way (Glen, 2014).

Within the broad domain of ICT, a relevant amount of contributions focused on the issue of Internet governance (IG) (Flyverbom, 2016; Musiani, 2015; van Eeten & Mueller, 2013). As some authors pointed out, it is important to state that the analyses on Internet governance offer interesting perspectives also on the broader domain of digital technologies, such as the more recent issues of datafication and algorithms (Flyverbom, 2016). Furthermore, IG embraces many more topics and elements than what the original stream of literature considered relevant (van Eeten & Mueller, 2013). For these reasons, IG contributions are worth considering, highlighting some interesting viewpoints useful for the whole analysis.

1.1.1 The Internet governance

"Internet governance" is a concept that was introduced around the mid-Nineties. In 1996, two Harvard scholars began studying the issue, especially focusing on disputes on websites' domain names and the transformation of the domain name system (DNS) (Hofmann et al., 2017). For the sake of clarity, the DNS is a system that "helps users to find their way around the Internet. Every computer on the Internet has a unique address – just like a telephone number – which is a rather complicated string of numbers. It is called its "IP address" (IP stands for "Internet Protocol"). IP Addresses are hard to remember. The DNS makes using the Internet easier by allowing a familiar string of letters (the "domain name") to be used instead of arcane IP address" (ICANN, n.d.).

In 1998, the Internet Corporation for Assigned Names and Numbers (ICANN) was founded by a U.S. Government initiative, which wanted to appoint the policy and technical management of the DNS to a non-profit corporation (ICANN, n.d.; Palfrey, 2004). After the foundation of ICANN, the research on Internet governance started focusing more on the institutional elements, analyzing the actors involved in it and the

policies that were developed (Hofmann et al., 2017).

The second phase of Internet governance research emerged with the World Summit on the Information Society (WSIS), which took place in two steps in 2003 and 2005 (*ibidem*). The WSIS was endorsed by the UN General Assembly. During the first phase held in Geneve in 2003, the institutional representatives of several countries, along with people from the civil society and the private sector, reflected on the need of an "Information Society for all". In the second phase, held in Tunis in 2005, the involved representatives tried to move to a more operative stage, with the aim of putting into practice what was developed in Geneve (WSIS, 2006).

From an IG literature point of view, the World Summit on the Information Society produced a since then widely used definition of Internet governance (Hofmann et al., 2017; van Eeten & Mueller, 2013): "Internet governance is the development and application by Governments, the private sector and civil society, in their respective roles, of shared principles, norms, rules, decision-making procedures, and programmes that shape the evolution and use of the Internet" (WGIG, 2005). It should be noted how this definition clearly shares many elements with the OECD's technology governance one previously presented, especially in identifying the Internet as a social environment where several actors play a role.

While the ICANN and WSIS carried out their activities, scholars started analyzing them, considering the characteristics and the evolution of these institutions (Froomkin, 2003; H. Klein, 2004). They studied the relationships between different players within WSIS. It emerged that governments held a significantly larger role compared to the civil society and the private sector (Kleinwachter, 2004). Other contributions focused also on the failures of these institutions, considering, once again, the lack of involvement of players other than public institutions (Palfrey, 2004).

Later analyses criticized the literature on IG that emerged in those years because it focused more on the inquiry of the international agreements, on the study of the decision-making process within the different institutions, and on the institutions themselves, instead than developing the comprehension of the Internet governance (Flyverbom, 2016). It has been noticed how the main concept of the field of IG was not further elaborated, since the primary focus of the analysis was the institutions involved in the governance of digital technologies (van Eeten & Mueller, 2013).

Furthermore, most recent contributions have been showing how private actors play a big role as well, which, despite being recognized even in the first definition of IG by WSIS, was not widely considered (DeNardis, 2012; DeNardis & Hackl, 2015; Flyverbom et al., 2019). Laura DeNardis (2012) showed that even though focusing on institutions involved in Internet governance is important, it contributed to shifting the attention away from the key players that define the technical architecture of the digital domain, namely private players. The role of the private industry extends also to the regulation of content available online and the managing of the flow of information via the Web. In another contribution, the author shows how Internet governance

is also pivotal for social media platforms. On the one hand, the private companies that own the platforms are “intermediaries providing citizens with access to the digital public sphere” (DeNardis & Hackl, 2015, p. 769). On the other, they are gatekeepers of the innovations that happen on their platforms (*ibidem*): take for instance the familiar case of a new mobile application that requires approval by Apple or Google to become available on the Apple Store or the Google Play Store.

Hofmann and colleagues added their voice to the ones that consider the analysis on Internet governance too much focused on the role of public institutions. In the authors’ view, this state-centric perspective is not able to grasp the complex interaction between several players that happens in the digital domain (Hofmann et al., 2017). While other contributions pointed out how in recent times, with the growing complexity of the Internet, a single actor entitled to Internet governance cannot be identified since many players share influence on the matter; be them governments, private companies, groups of experts, or users (Flyverbom, 2016; Flyverbom et al., 2019; van Eeten & Mueller, 2013).

A great example that could help better picture the idea that contemporary Internet governance is often not a national and supranational public institutions’ matter has been presented in the already mentioned DeNardi’s work (2012). The author describes the Wikileaks story, showing the “arrangements of power” that characterized the case.

Wikileaks is a “multi-national media organization and associated library […] founded by its publisher Julian Assange in 2006. WikiLeaks specializes in the analysis and publication of large datasets of censored or otherwise restricted official materials involving war, spying and corruption” (WikiLeaks, 2015). DeNardis (2012) clearly describes what happened around the end of 2010, when Wikileaks published correspondences between the US Department of State and American diplomatic representatives around the world. Besides a large debate on whether this content should have been published or not, a series of interesting episodes developed, the so-called “technical infrastructure wars”, which offer relevant elements to better understand contemporary IG. The quickest and toughest retaliation against WikiLeaks came from private companies. The website wikileaks.org was deleted from the Internet by the company that was providing the domain name system services. The organization, however, was able to come back online under another domain name. Another company that went after Wikileaks was Amazon, which stopped hosting two websites related to the publication of the secret documents related to the organization. Furthermore, payments companies such as PayPal, MasterCard, and Visa denied the money transfers to Wikileaks. All the involved private companies stated that Assange’s organization was somehow violating their terms of use and therefore strong actions were required.

Soon after, hackers entered the arena. The hacker group Anonymous attacked the websites that damaged Wikileaks with a technique called distributed denial of service (DDoS). The web pages of all the companies previously mentioned experienced significant problems because the hackers performed an enormous

amount of access requests that crashed the websites.
As DeNardis points out: “Both sides of the WikiLeaks battle – those choosing to disrupt the WikiLeaks site technically or financially and those choosing to retaliate for these actions – were not government actors. Private industry and private citizens play a considerable role in governing the flow of information and currency online” (DeNardis, 2012, p. 733).

While it has been shown the increased function of private companies in IG in most recent times, the pivotal role of public institutions, especially in the early days of the Internet, should not be disregarded. From another stream of literature come relevant suggestions with respect to this topic. Mariana Mazzucato argues that the State plays a key role in pushing technological innovation commissioning contracts to private players, bearing significant costs, and taking big entrepreneurial risks. In Mazzucato’s view, the liberal perspective has been promoting the idea that the State should just provide infrastructure and set rules – the fewer, the better – to enable private players to innovate. Conversely, there are many examples where the public sector has undertaken big risks and committed to big investments to promote both basic and advanced research that no private firm or venture capitalist was willing to take (Mazzucato, 2011, 2021).
The Internet itself started as a State-funded project since its progenitor, the ARPANET, was developed by the US Department of Defense’s Advanced Research Projects Agency (ARPA). The US military also played a pivotal role in developing the infrastructure that would later become the Internet. Similarly, the World Wide Web, created by Tim Berners-Lee, was initially developed at Geneve’s laboratory of the European Council for Nuclear Research (CERN) (Abbate, 1999). Coming to more contemporary episodes in the development of the Internet, even the Google Search algorithm, the first and most popular product of Google, was created also thanks to a National Science Foundation grant (Mazzucato, 2011). Other digital innovations benefit from initial public support, for instance, the GPS was founded by the US navy, the touchscreen was backed by the CIA, and Apple’s Siri was supported by the US Defense’s Advanced Research Projects Agency (Mazzucato, 2021).
Leaving for a moment the domain of digital technology, recent evidence on the role of public institutions in promoting technological innovation emerged during the COVID-19 pandemic. It has been shown how, reconstructing the source of funding for R&D on vaccines in the last 20 years, public and charitable institutions covered 97%-99% of the financing costs of the COVID-19 Oxford-Astrazeneca vaccine (Cross et al., 2021). It seems an additional element that supports Mazzucato’s stance with respect to the entrepreneurial role that the State plays when it comes to sustaining and promoting innovation (Mazzucato, 2011).

Two different literature streams in analyzing specific Internet’s characteristics seem to elaborate contrasting views, stressing, on the one hand, the increased role of private actors in affecting Internet governance (DeNardis, 2012), while on the other stating that public institutions are pivotal in promoting technological

change, also when information and communication technology are involved (Mazzucato, 2011). Clearly, these two positions are not incompatible, and they found touching points in the definition of technology governance that was reported in the opening of the paragraphs, which states that it is a matter of "formal government activities, but also to the activities of firms, civil society organizations and communities of practice" (OECD, 2019). A broad perspective on the study of digital technology must take into consideration the "arrangements of power" (DeNardis, 2012) that lie behind technology governance, trying to understand which actors had greater influence, but moving from a starting point where all their roles are analyzed.

1.2 Firms, platforms, and infrastructures in the capitalism's turn to data

Extracting, managing, and using large amounts of data can be considered the main asset of the present times and a new kind of capital, which contemporary capitalism started employing since it was facing declining profits from manufacturing (Sadowski, 2019; Srnicek, 2017). As Jathan Sadowski (2019) points out, throughout the years many authors differently labeled this relationship between data and capital, but a common ground seems to emerge. Despite having some differences, reflections on "platform capitalism" (Srnicek, 2017), "platform society" (van Dijk et al., 2018), "surveillance capitalism" (Zuboff, 2015), and "information capitalism" (Fuchs, 2010) share "common themes and conclusions" (Sadowski, 2019, p. 2). Many authors argue how, within this new way of doing business, firms gather and analyze customers' data to predict behaviors for commercial purposes and turn people's information in exchange value for products or services (Alaimo et al., 2020; Hulsey & Reeves, 2014; Zuboff, 2015, 2019).

Data have become so valuable that some companies even build their business on data trading, while data marketplaces are emerging and are expected to flourish (Spiekermann, 2019). Within an economy largely based on the exploitation of sources of information, the power is in the hand of those who can manage this information, namely tech firms (Arvidsson, 2016; Beer, 2018; Hintz et al., 2017).

The role of data in contemporary business made the expression "data is the new oil" popular to the point that it has become a sort of cliché (Couldry & Mejias, 2019). This expression aims at stressing the importance and value that emerge from data comparing it to the role that oil had in business back in the days. "Data is the new oil" has been widely discussed, analyzing differences and similarities between the two commodities (AGCOM, 2018; König et al., 2020; Sadowski, 2019). There is no need to deepen and argue on those here. Conversely, it could be interesting to consider - as an example of one way in which this expression could be interpreted - the market capitalization of global firms in the last twenty years, focusing on the top five positions. How *Table 1* shows, since 2015 the most valuable companies have steadily become tech firms, which have increased their influence in most recent times and overtook companies from other industries, especially oil and gas. This is additional evidence of the centrality of data and digital technologies in contemporary business, and a demonstration that - at least from the ability to generate economic value - "data is the new oil".

Table 1 - Top 5 firms for market cap 2021 - 2001

Rank	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012
1	Apple	Apple	Microsoft	Apple	Apple	Apple	Apple	Apple	Apple	Apple
	2,339,000	1,981,000	1,062,000	1,091,000	791,726	604,475	621,939	603,277	433,100	625,348
2	Microsoft	Microsoft	Apple	Amazon	Alphabet	Alphabet	Google	Exxon Mobil	Exxon Mobil	Exxon Mobil
	2,119,000	1,592,000	1,012,000	976,650	664,550	535,660	407,870	401,094	378,716	422,128
3	Alphabet	Amazon	Amazon	Microsoft	Microsoft	Microsoft	Microsoft	Microsoft	Berkshire Hathaway	PetroChina
	1,777,000	1,577,000	858,680	877,400	568,965	447,290	347,432	381,960	280,002	253,853
4	Amazon	Alphabet	Alphabet	Alphabet	Amazon	Amazon	Berkshire Hathaway	Google	Microsoft	Microsoft
	1,664,000	999,570	838,020	839,740	459,435	393,030	318,180	361,998	277,221	249,490
5	Meta	Alibaba Group	Berkshire Hathaway	Berkshire Hathaway	Berkshire Hathaway	Exxon Mobil	Exxon Mobil	Berkshire Hathaway	Johnson & Johnson	Walmart
	956,890	795,400	508,530	523,520	451,840	358,519	304,245	340,055	244,299	248,074

Rank	2011	2010	2009	2008	2007	2006	2004	2003	2002	2001
1	Apple	Exxon Mobil	Exxon Mobil	Exxon Mobil	Exxon Mobil	Exxon Mobil	General Electric	General Electric	Microsoft	General Electric
	353,518	314,623	329,725	403,366	513,362	398,906	382,233	299,336	264,003	372,089
2	Exxon Mobil	PetroChina	PetroChina	PetroChina	General Electric	General Electric	Exxon Mobil	Microsoft	General Electric	Microsoft
	353,135	270,890	325,098	325,098	424,191	364,414	380,567	271,911	259,647	326,639
3	PetroChina	Apple	ICBC	ICBC	China Mobile	Microsoft	Microsoft	Exxon Mobil	Exxon Mobil	Exxon Mobil
	276,474	259,223	237,952	237,952	327,937	272,679	262,975	263,940	241,037	299,820
4	IBM	Petrobras	Microsoft	Microsoft	ICBC	Gazprom	Citigroup	Pfizer	Walmart	Walmart
	208,844	220,617	229,631	229,631	279,269	254,634	234,437	261,616	234,399	273,220
5	Microsoft	ICBC	HSBC	HSBC	Microsoft	Citigroup	BP	Citigroup	Pfizer	Citigroup
	208,535	213,364	198,561	198,561	276,202	246,727	221,365	259,191	195,948	255,299

Digital platforms Oil and Gas Finance

*Source: own elaboration on data from "*List of public corporations by market capitalization"[1]

The pivotal role of data in firms' activities is also one of the main elements of a new way of organizing business that emerged most recently, especially in the digital sector: the platform.

The concept of "platform", and the connected field of study, gained success in recent times in the analysis of digital cultures (Steinberg, 2021). Scholars have been debating on the definition of platform and its main characteristics, on whether they should be considered more as firms or more as markets (van Dijck et al., 2019; West, 2019). As most of the time happens, the solution lies in the middle of the two concepts. Therefore, despite the struggle in reaching a precise and comprehensive definition, literature agrees on recognizing to platforms both the features of firms and markets. Moreover, there is a quite broad agreement

[1] "List of public corporations by market capitalization", Wikipedia, https://en.wikipedia.org/wiki/List_of_public_corporations_by_market_capitalization#2019, Retrieved on March 2022.

on considering platforms as intermediaries for digital activities between users, service or product providers, advertisers, and even physical objects, and as entities that have the aim to collect, produce and accumulate data (Spiekermann, 2019; Srnicek, 2017; van Dijck et al., 2019; van Dijk et al., 2018; West, 2019). Despite platforms are often described as a new type of business organization that largely developed within the digital and online domain, some contributions argue that part of their characteristics could be already spotted in previous models, such as Toyotism (Steinberg, 2021), and that platform capitalism is an evolution of finance capitalism (Sadowski, 2019).

Van Dijk and colleagues (2018) argue that two types of platforms exist: sectoral platforms and infrastructural platforms. With respect to the former, these kinds of organizations provide digital services for a specific domain, for instance, Airbnb is involved in the hospitality sector. Most of the time, sectoral platforms "have no material assets, have no sector-specific employees, and offer no tangible products, content, or services; they are merely "connectors" between individual users and single providers" (van Dijk et al., 2018, p. 16). Platforms have reshaped the organizations of several human activities such as working, enjoying leisure time, for instance through playing games or cultural products consumptions, and even dating or building new interpersonal relationships (Barra & Sartori, 2022).

On the other hand, infrastructural platforms "form the heart of the ecosystem upon which many other platforms and apps can be built. They also serve as online gatekeeps through which data flows are managed, processed, stored, and channeled. Infrastructural services include search engines and browsers, data servers and cloud computing, email and instant messaging, social networking, advertising networks, app stores, pay systems, identification services, data analytics, video hosting, geospatial and navigation services, and a growing number of other services" (van Dijk et al., 2018, p. 13).

Infrastructure studies, which more directly emerged from STS scholarships, described infrastructures as having ubiquity, invisibility, reliability as main characteristics. It has been shown how these elements characterized certain digital platforms as well (Plantin et al., 2018; Srnicek, 2017), making them very powerful actors (van Dijck et al., 2019). Infrastructural platforms have raised enormous amounts of power in contemporary societies since they developed solutions that have become almost essential for interactions between users, either for business activities, social interchanges, information seeking, or entertainment. The power accumulation of platforms developed through the control of global networks of users' communication and the constant and repeated gathering of useful data (Couldry & Mejias, 2019; Van Dijck, 2020; van Dijck et al., 2019). Literature shows how the power that platforms get from these enormous networks makes them the gatekeepers of the network itself and the services that can run on their infrastructures (Srnicek, 2017). Infrastructural platforms become the service providers also for other platforms, take for instance the case of Airbnb which relies on Google Maps to locate the host position in their website, and it employs Facebook's and Google's identification systems to manage users (van Dijk et al., 2018).

Most importantly, even National Governments nowadays find themselves in the condition of relying on

platforms' infrastructures and services. What they can get from platforms perhaps works better, it is faster to implement, and probably even cheaper than what they could develop by themselves. It is the case of the UK's National Health Systems that relies on Alphabet-Google's Deep Mind service to apply machine learning to patients' data and improve their services (Greene, 2018; van Dijk et al., 2018).

When dealing with digital technologies, many ambiguities between State actors and multinational corporations emerge, since decisions related to technical aspects have become an issue for both public and private forums, with an alternating predominance of one of the two (Chenou & Radu, 2019; Graz, 2006). In such a recently emerged domain, at the general level, the relationships among the actors and their influence over the governance of the processes are still in the making (King & Les Galès, 2017), with tech corporations behaving as political actors in certain situations (Whelan, 2019), and institutional actors wanting to intervene in the definition process of certain technologies (Flyverbom, 2016).

With respect to the relationship between digital platforms and public institutions, one of the most popular and analyzed cases is the one involving Google and the right to be forgotten. In 2014, a Spanish man claimed that his image was being damaged by an old judiciary case that he had more than fifteen years before. The episode kept appearing every time his name was entered in Google since it was reported by a local newspaper back in the days. Spanish authorities as well as The European Court of Justice were involved, and the latter decided that Google needed to delete the information upon user's request since the right to have data forgotten stands within the Union (Frantziou, 2014). Besides the judicial case that has been widely analyzed by law literature (Frantziou, 2014; Post, 2018; Singleton, 2015), this episode shows evidence of the hybridization of public institutions and digital platforms' powers and competencies. The Court decision gives Google the responsibility to evaluate users' requests on deleting information that is considered to violate rights, turning "the company into a quasi-legal organ" (Chenou & Radu, 2019, p. 76). Furthermore, public institutions cannot guarantee that the right to be forgotten is enforced without the help of the private company that manages the online information. Within this scenario, digital platforms gain significant new responsibilities in managing digital technologies, and sometimes they set rules within the space in which they operate that have more influence than legal restrictions (Chenou & Radu, 2019; Gillespie, 2017).

Therefore, it quite clearly emerges how infrastructural platforms have gained significant power in recent times, extending their influence beyond the markets in which they initially started operating and reaching the whole society (Van Dijck, 2020; van Dijck et al., 2019). They developed a significant amount of power that crowned them as gatekeepers of several online and digital ecosystems, in which private firms developed their own set of rules and guiding principles (Gillespie, 2017; van Dijck et al., 2019).

1.3 Privacy: from an individual to a collective matter

Privacy is not just a matter of the online world or the digital domain. In their offline interactions, people often carry out behaviors to protect aspects of their life that are considered too personal. Take for instance the

case of lowering the volume of the voice when telling something private to a friend or getting away from others when receiving a personal call (Acquisti et al., 2020). Furthermore, privacy is not just a matter of contemporary times either. One of the first academic contributions that reflected on this topic back in the XIX century lamented that "instantaneous photographs and newspaper enterprise have invaded the sacred precincts of private and domestic life; and numerous mechanical devices threaten to make good the prediction that "what is whispered in the closet shall be proclaimed from the house-tops"" (Warren & Brandeis, 1890, p. 195).

However, the matter of privacy raised to a whole another level in recent times due to the advent of digital technologies. Since the Eighties, when personal computing was born and with the later evolution of the world wide web, mass communication and marketing started to heavily rely on the gathering and use of consumers' information. A trend that grew exponentially within the past fifteen years with the diffusion of smartphones and the increase of online activities by users (Barth & de Jong, 2017; Shklovski et al., 2014). The large amount of time spent online by people and the numerous actions carried out through different websites and apps leave traces and information behind, which has become a valuable asset both for firms and governments, as already mentioned (van der Vlist, 2017; Zuboff, 2015). The newest developments of digital technologies contributed to penetrating the most diverse domains of human life, extending the information gathering not just to direct activities carried out online by users. It is the case, for instance, of smart speakers, also known as home personal assistants. Through the commercial solutions offered mainly by Amazon, Google, and Apple, the familial and social spaces of customers have become a valuable source of information (Burdon & Cohen, 2021; Pridmore et al., 2019; Pridmore & Mols, 2020; West, 2019). A similar case is the one of fitness and health trackers that through wearable devices measure several life parameters, from the heart rate to the quality of sleep (Gidaris, 2019; Sanders, 2017).

Within this evolved scenario, where information has gained such a big role, privacy becomes one of the main issues to consider (Acquisti et al., 2015).

In the broad realm of social sciences, the contributions that have been reflecting and researching on the issue of privacy in the digital domain largely focused on people's attitudes and behaviors when dealing with this kind of matter.

Scholars showed how privacy perception varies across different cultural contexts. So, for instance, while having similar positions on privacy risks, people from the U.S. and Europe have different opinions on possible regulating systems. The former prefer more autonomy and responsibilities on private firms; while the latter hope for strong State regulations (Dogruel & Jöckel, 2019; Helm & Seubert, 2020). Conversely, in Japan, many theoretical contributions assumed that because of the collectivistic nature of the country people do not value privacy much. It has been shown that this kind of mindset granted support for government surveillance

activities, while some criticisms emerged for privacy-violating behavior carried out by private companies (Luther & Radovic, 2012).

Another relevant stream of research that has been analyzing users and privacy is the one that considers their comprehension and understanding of this matter. Within a constantly evolving landscape of digital technologies and online solutions, users cannot rely on complete information when it comes to the exploitation of their personal data. It is increasingly complicated to understand which kind of information other users, firms, or governments could access and what is their actual value (Acquisti et al., 2015, 2020; Pilton et al., 2021). This lack of information contributes to increasing uncertainty over privacy, an element that also emerges in preferences over this element. Not being fully aware of the personal information that has been left behind online tends to decrease users' worry about data mismanagement and significantly influence privacy preferences (Acquisti et al., 2015; Furini et al., 2020).

Over the issue of privacy preferences and attitudes, a huge debate has been developing among scholars, and it goes under the name of "privacy paradox".

Privacy paradox regards the fact that "on the one hand, users express concerns about the handling of their personal data and report a desire to protect their data, whereas at the same time, they not only voluntarily give away these personal data […] but also rarely make an effort to protect their data actively" (Gerber et al., 2018, p. 227). The many studies on this topic however have not yet come out with complete explanations and united positions on this gap between attitudes and behaviors towards privacy (Barth & de Jong, 2017; Gerber et al., 2018; Kokolakis, 2017).

Nevertheless, scholars have been questioning themselves about possible causes of this paradox and they have found some answers. First of all, a substantial issue of interpretation emerges: it is hard to define from the researcher's point of view whether the perceived value of privacy expressed by an individual is too low or too high. Secondly, privacy is a contextual phenomenon, namely, people demonstrate different behaviors towards their privacy depending on the situation around them. Finally, personal information is a very diverse object with different values attached, for instance, people may evaluate differently sharing information about their location and their date of birth (Kokolakis, 2017). Moreover, to add complexity to the analysis of the privacy paradox, an issue of methodology emerges. As the literature review contributions show, the two main research methodologies are surveys and experiments (Gerber et al., 2018; Kokolakis, 2017). On the one hand, the former cannot grasp the actual users' behavior towards privacy; on the other, the latter presents significant issues of generalizability (Kokolakis, 2017).

Despite this last methodological limitation, also based on the study of the causes that lie behind the privacy paradox, scholars started suggesting that it should not be considered as a paradox at all. A gap between people's attitudes and behavior towards privacy clearly emerges, but the two do not contradict one another because one regards broader considerations on the issue, while the other is related to context-specific

decisions (Kokolakis, 2017; Solove, 2021). Scholars have been studying also possible decisional mechanisms that influence people's privacy choices. For instance, some contributions argued that people have become cynical about their privacy because of the lack of control on it (Hoffmann et al., 2016). Other contributions suggested that the benefits of participating in the online world outweigh perceived damages, or that being online is such a routinized activity that privacy evaluations are suspended. Moreover, other studies have shown how privacy decisions are influenced by cognitive biases, limited information, or wrong representations of own privacy (Barth & de Jong, 2017; Kokolakis, 2017).

This corpus of studies that may appear just as theoretical speculation, indeed holds significant implications to both online commercial activities and public policy regulations. Whether it would ultimately emerge that users actually discount privacy through their behavior, private businesses could have larger justification to continue and increase online information gathering, while governments would have fewer premises to trying limit this kind of activities (Kokolakis, 2017).

As the privacy paradox debate also shows, privacy is largely considered as an individual matter. Scholars have argued how this shared perspective comes from the liberal tradition of individualism where not only material properties belong to individuals, but also the immaterial elements, such as personal information (Fairfield et al., 2015; Helm & Seubert, 2020; Huey, 2012). The idea of privacy as an exclusively personal matter also influenced the way of protecting privacy which is often related to informing individuals and making them choose whether to opt-in services. These approaches do not seem successful because people are overwhelmed by privacy notices and are often obliged to accept if they want to participate in the online world (Fairfield et al., 2015; Helm & Seubert, 2020).

Furthermore, considering privacy just as an individual issue contributes to shrinking the concept's width, relegating it to an analysis based exclusively on its legal and rights implications (Bennett, 2011; Waldman, 2015).

Therefore some scholars suggested that reflections on privacy should start focusing also on contextual elements around the individual and extend its boundaries toward groups of people, considering privacy as a collective matter (Coll, 2012). Alongside the appearance of numerous studies on the economic values of personal information (Alaimo et al., 2020; Hulsey & Reeves, 2014; Zuboff, 2019), in more recent times, scholars develop a consistent collective view on privacy, even though it was a perspective that was already introduced decades ago (Regan, 2002).

A collective view on the issue of privacy emerged in many fields of study. Within law and economy, scholars reflected on the concept of "public good" with respect to privacy. They showed how personal data are not just about a singular person, but it can tell relevant information also about people that surround the person or it could have some effects on others as well (Fairfield et al., 2015; Sætra, 2020).

In philosophy, contributions focused on the privacy of the group, suggesting that there is a certain type of

personal information that can affect groups of people, therefore besides individual privacy also the privacy of the group as a whole should be considered (Floridi, 2017; Mittelstadt, 2017; Taylor et al., 2017).
Coming to social sciences *stricto sensu*, the need to shift towards a more collective perspective on privacy has been justified due to the type of relations that happen online. The online world asks for a reformulation of the concept of individual autonomy, in the sense of an increasingly networked self. A relational understanding of autonomy clearly involves also a redefinition of privacy which is not exclusively based on the idea of individual protection of personal information (Helm & Seubert, 2020; Huey, 2012).

With respect to privacy within sociology, due to the previously presented idea that privacy has been largely considered as an individual matter, the issue has been marginal to the discipline. However, scholars have recently argued how privacy has significant social implications. Understanding how privacy is managed and perceived within society has a direct and profound impact on people's social life, constituting a relevant element of social interactions instead that an exclusive individual good that is experienced personally (Kasper, 2016; Waldman, 2015).
Nevertheless, a definition of privacy within sociology remains a complicated task and an established stream of literature seems still under development (Anthony et al., 2017). The complexity of a such task increases because the issue of privacy is relevant for many research topics like surveillance, freedom, feminism, and the body (Kasper, 2016; Solove, 2008).
However, one of the main takeaways of sociological analyses on privacy is that it is a matter highly dependent on the contextual factors and the environment around a person or a group (Anthony et al., 2017). It is a reflection somehow already formulated, using different terms, in the work of Georg Simmel (Coll, 2012). In "The Sociology of Secret and of Secret Society" the German sociologist wrote that it is like "that an ideal sphere surrounds every human being, different in various directions and toward different persons; a sphere varying in extent, into which one may not venture to penetrate without disturbing the personal value of the individual. Honor locates such an area. Language indicates very nicely an invasion of this sort by such phrases as "coming too near" (zu nahe treten). The radius of that sphere, so to speak, marks the distance which a stranger may not cross without infringing up, on another's honor. Another sphere of like form corresponds to that which we designate as the "significance" (Bedeutung) of another personality. Towards the "significant" man there exists an inner compulsion to keep one's distance" (Simmel, 1906, p. 453). Considering privacy as context-dependent offers an interesting perspective also on the debate around the "privacy paradox" that was previously presented.
In general, from a sociological point of view, privacy is a matter of balance between the individual dimension and the societal one, between closure and openness, between sharing information or keeping it private, and it is a balance that involves not just the individual, but also other people, as well as companies and public institutions (Anthony et al., 2017).

The issues that a sociological perspective on privacy raises are strictly related to policymaking activities on this matter. Regulating bodies need to cope with the need of gathering, evaluate, and study data to foster innovation and people's right to protect their personal information. When dealing with privacy and data protection at the public institutions level, analyzing a recent and decisive development in the European regulatory framework, namely the General Data Protection Regulation (GDPR), could offer interesting perspectives on this issue.

1.3.1 The EU General Data Protection Regulation

The EU's attention towards privacy and data protection dates back some decades, indeed, in 1970 in the federal state of Hassen in Germany, a first law on data protection was promulgated. It progressively emerged how a local statute on data protection was not really effective since data could be moved around to circumvent regulations (Phillips, 2018). Later on, in 1995, the European Union developed the Data Protection Directive which tried to offer a common regulatory framework for privacy and data protection (Almeida Teixeira et al., 2019; Phillips, 2018). With the emergence of digital technologies, the rules that were developed in the first half of the Nineties quickly became outdated and required a new set of laws and principles. To reach this goal, the GDPR was approved in 2016 and enforced in 2018, introducing new rules to give citizens more control over their personal information and try to unify the whole continent under the same principles of data protection (Almeida Teixeira et al., 2019).

The GDPR established more clearly a sort of "European way" in dealing with privacy and data protection. If, on the one hand, the U.S. law considers the main *locus* of privacy the home, on the other, the EU perspective includes also the protection of family life, reputation, and data processing (Hoofnagle et al., 2019). Furthermore, especially when dealing with information and communication technologies, the EU focus shifts towards considering privacy as data protection, which is a slightly different concept with respect to privacy. Data protection regards the issue of using data properly for aims and scopes that are fair and justified. It is a more specific and compatible goal when dealing with digital technologies than the focus on keeping elements of life private, which is more related to the concept of privacy (Regulation (EU) 2016/679, 2016; Fairfield et al., 2015). Experts argue that the GDPR opened a "value-friendly "third way" to navigate the digital world, in between the "techno-libertarianism" of US Silicon Valley and the "digital authoritarianism" of China" (Marelli et al., 2021, p. 2).

The GDPR builds on the idea that data protection is a fundamental right (Hoofnagle et al., 2019). As stated in Article 8 of the Charter of Fundamental Rights of the European Union, "everyone has the right to the protection of personal data concerning him or her. Such data must be processed fairly for specified purposes and on the basis of the consent of the person concerned or some other legitimate basis laid down by law. Everyone has the right of access to data which has been collected concerning him or her, and the right to have it rectified" (2012/C 326/02, 2012, p. 397). Moving from these tenets, the GDPR expresses six principles

for processing personal data. Data need to be "processed lawfully, fairly and in a transparent manner in relation to the data subject […], collected for specified, explicit and legitimate purposes […], adequate, relevant and limited to what is necessary in relation to the purposes for which they are processed […], accurate and, where necessary, kept up to date […], kept in a form which permits identification of data subjects for no longer than is necessary for the purposes for which the personal data are processed […], processed in a manner that ensures appropriate security of the personal data" (Regulation (EU) 2016/679, 2016, p. 6).

The GDPR has many relevant elements, such as providing a relevant definition of data protection and the so-called "data subject", namely the person who has the right to data protection, but a more in-depth analysis of these and other elements exceeds the aim of this work. However, it could be interesting to mention that the EU regulation includes guidelines on the "right to be forgotten", an issue that has been previously considered. It states that individuals can require the elimination of personal data if data are no longer necessary with respect to the purpose of collection (Boban, 2018).

Moreover, the GDPR has been a quite discussed topic even during the COVID-19 pandemic. Several scholars considered whether the EU regulation was adequate in such a time of crisis, where the extensive use of personal data was sometimes necessary. The broad and general conclusion to which a review of different studies comes is that the GDPR lived up to this challenge and appeared to be a proper regulatory framework even in this complex situation (Christofidou et al., 2021).

2. The socio-technical perspective and the other perspectives on DCT

2.1 The early under-development of the socio-technical perspective

In the early months of DCT design, implementation, and use, very few studies specifically related to the entanglement between the social and technological dimensions of the issue of interest were produced. Among this small number of contributions, Vinuesa and colleagues (2020) framed the development of the tracing technologies as an issue of governance, technology's characteristics, and impact on citizens, showing how two conflicting views emerge. On the one hand, national public institutions need information and data to try to manage the pandemic, on the other, citizens want to protect their personal information and privacy (Vinuesa et al., 2020).

Other authors, despite not directly relying on the science and technology studies tradition, consider the role of citizens as co-producers of DCT. Citizens' involvement in the project is pivotal, first of all because they download the app and engage in DCT, but also because they offer suggestions. From the analysis of Tweets, it emerged that people's willingness to participate in DCT, even if framed as a co-production necessity, was hindered by concerns about possible data breaches or misuses (Polzer & Goncharenko, 2021).

Conversely, the socio-technical dimension of tracing technologies has been precisely stressed by Arakpogun and colleagues (2020) in the analysis of the implementation of DCT in Africa. The scholars stated how "any

adoption of DCT by African countries must take account of the compatibility of these design assumptions with local resources, values, social structures, domestic political factors and the reality of users in the African context" (*ibidem*, p. 1). Since the design context of the solutions does not match the context of use, a process of translation of both the technology and the related policies is required to give DCT a chance of working in Africa.

The two previously described issues of technology governance and the role of tech firms have not been largely explored in the early analysis of DCT either. Some authors briefly raised some concerns on the role of Apple and Google in the development of tracing technologies (Guinchard, 2020; Lucivero et al., 2020). Similar concerns have been expressed by Tamar Sharon (2020), who argues that "the (legitimate) advantage these actors have accrued in the sphere of the production of digital goods provides them with (illegitimate) access to the spheres of health and medicine, and more worrisome, to the sphere of politics. These sphere transgressions raise numerous risks that are not captured by the focus on privacy harms. Namely, a crowding out of essential spherical expertise, new dependencies on corporate actors for the delivery of essential, public goods, the shaping of (global) public policy by non-representative, private actors and ultimately, the accumulation of decision-making power across multiple spheres" (*ibidem*, p. 1). Furthermore, some more philosophical contributions mentioned the case of DCT, in analyzing the interplay between national institutions and private firms, also reflecting on the concept of digital sovereignty (Floridi, 2020; Taylor, 2021).

As months passed by, the socio-technical perspective on DCT was more largely explored, especially with respect to the role of Apple and Google, as the last paragraph of this section will show. However, the role of digital platforms in the development of DCT strategies was initially covered by traditional and online media, such as The Guardian (Hern & Proctor, 2020), Politico (Scott et al., 2020), and Tech Crunch (Etherington & Lomas, 2020; Lomas, 2020b). The media outlined the conflictual relationship between PEPP-PT and Apple and Google on the centralized and decentralized approach and the use of Bluetooth technology (Lomas, 2020b). Governments' position on this issue has been documented as well, reporting - among other things - Cedric O's, France's digital minister, statement on the need for France to not "be constrained by the internal policy choices of any company on a matter of public health" (Scott et al., 2020). Cedric O has been one of the main voices advocating for a centralized approach in the early phase of the pandemic and criticizing tech corporations, especially Apple, on the decision to limit Bluetooth's use for those who decided not to follow the decentralized approach (Criddle & Kelion, 2020).

While a socio-technical perspective on DCT developed after some months following the apps' release, many other analyses were initially produced on this topic, both in the social sciences and other disciplines. Here are the ones that seemed more relevant.

2.1 DCT, privacy and ethics

Privacy has been among the most discussed and analyzed topic with respect to the scientific production that focuses on DCT. First of all, scholars involved in the development of tracing solutions widely stressed this issue. Both the promoters of the centralized approach and the decentralized approach to digital contact tracing state that privacy-preserving technology is a priority (Fraunhofer AISEC, 2020; PEPP-PT, 2020b; Troncoso et al., 2020). It is interesting to notice how the expression "privacy" appears in the name of all the main DCT protocols: DP-3T (Decentralized Privacy-Preserving Proximity Tracing), ROBERT (ROBust and privacy-presERving proximity Tracing), PEPP-PT (Pan European Privacy Protecting Proximity Tracing). Furthermore, scholars, experts, and civil society organizations widely discussed about privacy (Siffels, 2020). Academic contributions basically stressed the importance to develop DCT solutions that do not harm users' privacy (Bengio et al., 2020; Lucivero et al., 2020).

An original perspective on this matter is offered by Zhang and colleagues (2020) who showed how, while users' privacy could have been protected by design, the way of communicating it to users was not very transparent. The authors analyzed privacy notices of seven contact tracing apps and concluded that they required above-average reading skills to be fully understood by users, possibly constituting an additional obstacle to app broad diffusion.

Scholars emphasize that privacy is not the only ethical issue with respect to DCT, mentioning many other dimensions (Gasser et al., 2020; Siffels, 2020). Among these, the ones related to the voluntary download of the app are worth mentioning. Most of the contributions stressed the importance to leave users the choice to whether download the app or not, identifying as particularly bad any policy that would impose the use of tracing technologies (Klar & Lanzerath, 2020; Lucivero et al., 2020; Morley et al., 2020). With respect to this issue, June Park's (2021) perspective emerges from the crowd since she argues that voluntary participation in DCT largely reduces the possible positive outcomes of such technologies in the fight against COVID-19 because the apps would not reach a significant number of downloads.

Furthermore, additional interesting considerations emerged on the efficacy and proportionality of this intervention. Scholars reasoned on the risks connected to the use of this technology, such as privacy violation and surveillance, and the lack of elements that would ensure it to properly work, both from a technical point of view – Bluetooth technology is not made for measuring distance (Leith & Farrell, 2020a) – and a users' penetration one (Lucivero et al., 2020; Morley et al., 2020).

An interesting perspective is presented in a study focusing on the ethics of South Korea's interventions against Covid. It emerged how the Korean government considered the use of DCT as a proportionate intervention compared to the possible outcomes in terms of deaths among citizens that the forecasts were suggesting. Moreover, national authorities recognized that some privacy issues may occur, but they decided to prioritize public safety and public health with respect to possible data breaches. Finally, referring to the

aforementioned ethical issues of efficacy and proportionality and to the principle of necessity, a tension between two possible non-pharmaceutical solutions is described. On the one hand, lockdowns have been proved as more effective in slowing down the contagion, but the limitations they impose on people's lives are extremely significant; on the other, digital contact tracing is far less intrusive, but the results are equally less visible (Ryan, 2020).

2.2 Attitudes and behaviors towards DCT

Another relevant stream of literature related to social science that analyzed DCT is the one that considers people's attitudes towards these kinds of solutions, whether they actually use tracing technologies or not, and possible explanations for their behaviors.

A large study, realized in France, Germany, Italy, the UK, and the US with 5995 people, showed how the support to contact tracing apps prior to their launch was high in each context. 74.8% of the respondents across the five countries answered that would probably or definitely download the app. The researchers show how, even with large acceptance of this kind of technology, differences emerge between countries, with France and Italy having higher acceptability rates than Germany and the US (Altmann et al., 2020). The reported numbers change significantly in studies that analyze the actual use of the app instead of the intention of use. From a study conducted in Germany from June to August 2020, it emerged that 36.5% of the 4960 respondents have downloaded the app (Grill et al., 2021). From another study, always conducted in Germany during the first week after the app's release, resulted that also the willingness to install and use the app dropped to 35% (Blom et al., 2021).

This data are quite in line with evidence that emerged from a 1500 cases survey conducted in Australia, where 37.3% of the respondents downloaded the app, 27.7% refused to do so, 18.7% had the intention to do it, and the remaining 16.3% were undecided (Thomas et al., 2020).

An additional study has been realized in Switzerland after some months from the launch of the app, and it showed that 46.5% of the participants declared to use the national contact tracing app in October 2020 (von Wyl et al., 2021).

The contributions that focused on the attitudes and behaviors towards the use of DCT apps also tried to understand possible obstacles and enabler elements to the diffusion of these technologies. In line with the previously analyzed issue, many researchers identified privacy and data safety as the main concerns among citizens (Altmann et al., 2020; Elkhodr et al., 2021; Montagni et al., 2021; Zetterholm et al., 2021; Zimmermann et al., 2021). Trust in governments is another relevant dimension with respect to doubts in utilizing tracing technologies (Guillon & Kergall, 2020; Lucivero et al., 2021; O'Callaghan et al., 2021). While among the sociodemographic determinants that influence the use of DCT, it emerged that better education, higher income, and health literacy increased the likelihood of download (Grill et al., 2021). Technical abilities and comprehension of how tracing systems work seem to play a role as well. On the one hand, basic skills

enable to download and activate the app, while having a correct understanding of technology's affordances and characteristics contributes to reducing fear of privacy violation (Blom et al., 2021; Thomas et al., 2020). However, a study from Switzerland showed that ignorance and lack of information about DCT do not seem to be an issue in that context (von Wyl et al., 2021).

In general, from a review of many studies, it also emerges that the cultural context influences the acceptance of DCT solutions. Countries with a culture that shares values of collectivism and higher trust in governmental institutions generally have higher penetration rates compared to individualistic cultures, where mistrust towards institutions is more widespread (Zetterholm et al., 2021).

Most of this evidence emerges from a corpus of studies that mainly utilizes surveys as a research technique, focusing on several settings such as Australia (Thomas et al., 2020), Fiji (Sharma et al., 2020), France (Montagni et al., 2021), Germany (Blom et al., 2021; Grill et al., 2021), Republic of Ireland (O'Callaghan et al., 2021), and Switzerland (von Wyl et al., 2021).

However, also other contributions have been focusing on attitudes and behavior towards DCT employing diverse techniques and providing additional interesting results.

From a large-scale study that relied on interviews conducted in Austria, Belgium, France, Germany, Ireland, Italy, the Netherlands, German-speaking Switzerland, and the United Kingdom it emerged that people had the idea of trading their personal data to reach a greater good when using DCT apps. Elaborating on this expressed trade-off, the authors suggest that the idea of sacrificing personal privacy "reflects how the discussion on the ethics of contact tracing apps has been framed by public media, policy discussions, and in some scholarly debate. It is reasonable to believe that the wider public and media debate has played a role in shaping people's views" (Lucivero et al., 2021, p. 10).

Another interesting contribution, by analyzing online search history related to the Swiss app, shows how the political discussion on the development and implementation of the technology boosted the interest of the public even before the app was released (Glauser et al., 2020).

Other scholars focused more on the sentiment analysis of opinions expressed on social media towards the app. From the analysis of Twitter and Facebook posts in the UK, 76% of the analyzed contents had a positive sentiment, while 12% of them had a negative one. The study argues that these numbers are similar to the results emerged from a survey of almost 2000 UK adults (Cresswell et al., 2021). Conversely, a contribution that focused on Reddit posts obtained 49% of neutral sentiments, 30% of positive sentiments, and 21% of negative. The researchers also showed how, month after month, the share of neutral and positive sentiment decreased in favor of augmenting negative ones (Praveen & Ittamalla, 2020).

Evidence from focus groups confirmed what was suggested by certain quantitative studies (Thomas et al., 2020), namely that some people do not have a sufficient understanding of DCT's characteristics and of what this technology can and cannot do. The authors have suggested that this lack of understanding may be also

related to the deliberative choice made by some participants to avoid excessive information and news reporting on coronavirus "as a result of over-exposure to COVID-19 coverage and/or as a coping or avoidance strategy" (S. N. Williams et al., 2021, p. 383).

2.3 Technical and epidemiological aspects of DCT

Beyond the field of social science, the largest body of scientific studies on DCT considers its epidemiological and technical implications. Just to have an idea of the dimension of these streams, by searching on Scopus "digital contact tracing", and limiting the query to studies that have been realized from 2020 to January 2022, 202 works in the field of medicine emerge, 157 in the one of computer science, third comes social science with 97, while fourth engineering with 69 (Scopus, 2022). These numbers emerge from the automated classification of papers performed by the website, therefore they are not completely reliable, also because some works have been included in more than one category, since the overall number of contributions by January 2022 is 442. Nevertheless, they offer an interesting overview of the main fields of study that focused on tracing technologies.

One of the most significant streams of literature has been the one analyzing epidemiological implications of digital tracing technologies. Many scholars have been studying the impact of these solutions on the pandemic through mathematical models (Ferretti et al., 2020; Hinch et al., 2020; Salathé et al., 2020), tests, or experiments (Barrat et al., 2021; Hinch et al., 2020; Moreno López et al., 2020; Rodríguez et al., 2021), suggesting that tracing technologies could have a substantial impact in slowing down the contagion.

The contribution that received the largest attention is the one published on Science by Luca Ferretti and colleagues (2020). It was also one of the first scientific analyses to appear on this topic, being published in the first half of May 2020. The authors, relying on the knowledge available at that time on COVID-19, elaborated simulations on possible impacts of a contact tracing strategy based on digital devices. Ferretti and colleagues argue that, due to quick transmissions of the virus and the role that asymptomatic and pre-symptomatic individuals seemed to play in it, manual contact tracing is not a viable strategy to fight the spreading of the disease. Therefore, they suggest that an "approach, with a mobile phone app implementing instantaneous contact tracing, could reduce transmission enough to achieve $R < 1$ and sustained epidemic suppression, thereby stopping the virus from spreading further" (Ferretti et al., 2020, p. 6).

Other contributions tried to elaborate models of effectiveness for different interventions and their combinations (Shubina et al., 2021). Alain Barrat and colleagues (2021) argued how the effectiveness of DCT grew when combined with other NPIs, and in general when the number of positive cases is somehow already under control. Furthermore, other scholars showed that "strategies that combined isolation of symptomatic cases with tracing and quarantine of their contacts reduced the R_{eff} more than mass testing or self-isolation alone" (Kucharski et al., 2020, p. 1158). Moreover, through the analysis of real data, it has been argued how isolation and DCT imply the costs of having a high number of false positives, which translates into many

healthy persons being quarantined. However, “this last could be mitigated by testing the quarantined population and revealing the false negatives, thus translating the social cost in an economic burden due to swabs” (Cencetti et al., 2021, p. 9).
Other contributions also reflected on some additional elements that could affect the performance of DCT, such as smartphones’ penetration and testing precision (Rowe, 2020), and how privacy can constitute a tradeoff with the technology effectiveness (Seto et al., 2021).

Focusing more on the technical side of this non-pharmaceutical intervention, other scholars raised significant concerns about the efficacy of Bluetooth technology. Experiments showed how Bluetooth was not able to precisely measure the distance between two devices to the point that identifying the correct distance and therefore signaling the contacts was a quite random event (Leith & Farrell, 2020a, 2020b). Measurements conducted on public transportation “indicate that in the tram there is little correlation between received signal strength and distance between handsets. Similar ranges of signal strength are observed both between handsets which are less than 2m apart and handsets which are greater than 2m apart (including when handsets are up to 5m apart). This is likely due to reflections from the metal walls, floor and ceiling within the tram, metal being known to be a strong reflector of radio signals , and is coherent with the behaviour observed on a commuter bus” (Leith & Farrell, 2020a, p. 6).

An interesting experiment, aiming at studying both the technical feature of the app and its epidemiological one, has been conducted in one of the Canary Islands in Spain (Rodríguez et al., 2021). The researchers, moving from the lack of empirical evidence of DCT effectiveness, conducted a “4-week longitudinal population-based experiment” (*ibidem*, p. 2). It emerged that DCT seems to detect more secondary cases if compared to the manual one. More importantly, DCT was able to trace contact with strangers that would be almost impossible to record with other methods. After a promotion campaign for the app, the research reports that 33% of the population downloaded the app. Based on these results, the authors conclude that DCT could be a useful technology to manage an epidemic outbreak.

Current analyses on DCT also have important antecedents in scholarships that analyzed the technical sides of the issue. Throughout the years, scholars and scientists have been trying to measure, represent and understand people’s relationships and social graphs through digital technologies, striving to define the best technology to do so (Cebrian, 2021; Salathé et al., 2010; Smieszek et al., 2016). For instance, Marcel Salathé and colleagues (2010) conducted a study in a US high school on the transmission of infectious diseases using wireless sensor network technology.

Many more studies debated on the share of the population that should have been reached to make digital contact tracing useful against COVID-19. Mazza and colleagues (2021) offer a useful synthesis of the many contributions, showing how the numbers vary between 90% and about 60% of people using DCT apps.

Cencetti and colleagues (2021) supported with data from simulations the common-sense conclusion that a low adoption rate makes DCT useless, especially with a high number of infected people.
While most of the contributions were based on predictions, tests, and simulations of tracing technologies' use before their release, Wymant and colleagues (2021) analyzed the data available on the UK app four months after the launch. Of course, simulations and modeling were employed in this analysis as well since DCT apps' data are difficult to obtain, but it emerged that "a large number of cases of COVID-19 were averted by contact tracing through the NHS app, with estimates ranging from approximately 100,000 to 900,000, depending on the details of the analysis" (Wymant et al., 2021, p. 410).
However, in general, it has been argued that despite the different contributions, significant elements that prove DCT effectiveness are still lacking (Anglemyer et al., 2020; Mazza et al., 2021; Storeng & de Bengy Puyvallée, 2021).

2.4 The later development of the socio-technical perspective on DCT

As anticipated, later contributions engaged with socio-technical issues related to DCT more broadly, covering and analyzing different issues. Many authors further elaborated on the role of the two tech corporations Apple and Google. They described the two firms' dominance on public institutions with respect to DCT since they control the technical smartphones infrastructure on which DCT was supposed to be implemented (Busch et al., 2021; Dieter et al., 2021; Storeng & de Bengy Puyvallée, 2021). Scholars stressed how, in DCT development and use, Apple and Google worked as intermediaries between citizens and governments, acting as a sort of "quasi-critical global infrastructure" (Dieter et al., 2021). Conversely, some other authors argue that what happened during CTAs' design, implementation, and use has been a reciprocal dependency between public institutions and the two US tech firms. For certain aspects, mainly technological, the control was largely in the hands of Apple and Google, while for other aspects, such as the definition of guiding principles like voluntariness and data protection, it was more in public institutions' hands (Lazing et al., 2022).
Always reflecting on the role of public institutions and their relationships with technologies, other authors, building on recent STS contributions, argued how "the COVID-19 pandemic exemplifies the increasing salience of (digital) technologies in the governance of societies" (Metzler & Åm, 2022, p. 191).
Starting from the analysis of media outlets and users' reviews, scholars have also engaged with the socio-technical dimension of CTAs when exploring their non-functioning reasons. Especially with respect to the Italian app, it has been suggested that some of the problems that may have caused low usage rates were not related to technical problems of the app, but to "difficulties of knowing what to do, and who is in charge, after a subject is tested positive and wants to send notifications to the contacts" (Bano et al., 2021, p. 112).

This section of the chapter has shown the main and most discussed perspectives on COVID-19 DCT in the literature, namely privacy and ethics of tracing solutions, analyses of attitudes and behaviors towards them, and studies on their technical and epidemiological aspects. Socio-technical analyses on this matter were

largely underdeveloped in the early months after the apps' rollouts and during their design but started developing later. This work aims to develop even further this perspective, largely relying on the theoretical toolkit presented in the closing paragraph of the previous chapter. Investigating the socio-technical dimension of DCT implies studying this matter following the perspectives of relevant social groups involved in its design and implementation. Moreover, it means incorporating in the analysis the technical and material dimensions and considering their agency on what different groups of people have decided and scripted. It is no easy task, but it is essential to have more complete knowledge of a relevant aspect of the COVID-19 pandemic.

If the goal of this work has been stressed multiple times, the path to get there still needs to be accurately presented. The upcoming chapter intends to do so, describing the methodology, the research techniques, and the data analysis approaches, after having clearly expressed the research questions.

Chapter 3 – The research design

The different theoretical contributions analyzed in the first chapter clearly indicate the main paradigm to which this study needs to refer to. The social construction of technology's (SCOT) tradition holds in its name the reference to a socially constructed reality that has to be browsed through different actors' eyes. This ontological stance, strongly received by the previously defined theoretical framework, of course influences the epistemological orientation of the whole contribution. Within the continuum that runs from a deductive approach, totally informed by previous theory, and an inductive one, which is theory-blind (Kennedy & Thornberg, 2018), this work leans toward the latter pole. Nevertheless, it is quite clear that it is impossible to act as a researcher without having any influence from previous works on similar matters and related theoretical contributions (Braun & Clarke, 2006).

Moreover, always referring to the epistemological orientation of this work, the already described SCOT and ANT, and the soon-to-be-covered digital methods, act as significant guiding approaches when suggesting to "follow the actor" and "follow the medium". These two principles ask for diving into the research setting, giving relevance to both human and non-human actors, and gathering information that emerges from the proximity with them (Caliandro & Gandini, 2019).

With respect to the different types of research methods and techniques, this contribution follows the qualitative approach, employing semi-structured interviews and document analysis, and it furthermore utilizes digital methods, relying on the analysis of users' reviews scraped from online digital stores. It is tough to categorize this latter approach as either qualitative or quantitative since the boundaries between the two are quite blurred in digital methods (*ibidem*). Despite having these two different types of approaches, sticking to a more standard definition of mixed methods, which indicates researches that imply both a qualitative and quantitative approach, this contribution cannot be defined as such (Hesse-Biber, 2018).

These different research methods and techniques are part of the main framework that comprehends the empirical part of this contribution, namely the case study. Largely analyzed through the years, and defined either as a research strategy (Eisenhardt, 1989), a methodology (Harrison et al., 2017), or an empirical method (Yin, 2018), the case study that contributed guiding this work is presented in the following pages of this chapter. Before diving into the strengths and weaknesses of this research strategy, methodology, or empirical method for the present contribution, a precise definition of the main concepts involved in the research will be provided, as well as the statement of the research questions. The chapter will close on a timely description of the research methods and techniques which, as already mentioned, are the document analysis, semi-structured interviews with experts, and the analysis of users' reviews.

1. Studying a policy or a technological artifact? A misleading question

The focus of this work on digital contact tracing during the COVID-19 pandemic has been already stressed many times. It has been furthermore already stressed that DCT is just one of the many non-pharmaceutical interventions deployed to fight the spreading of the virus since the early months of 2020. The CoronaNet project, part of the Periscope consortium, funded by the European Commission under the Horizon 2020 Research and Innovation programme, is tracking "various fine-grained actions governments are taking to address the effects of the COVID-19 pandemic" (CoronaNet, 2020). Just from March 2020 to May 2020, over 13,000 policies against Covid have been recorded from more than 195 countries (C. Cheng et al., 2020). Among these policies lies several NPIs such as curfews, physical distancing, face masks, alcohol-based hand cleaning, remote working, lockdowns, and, of course, DCT (Flaxman et al., 2020; Perra, 2021).

Some of these interventions date back centuries or even millennia. For instance, during the XIV century, a 40 days quarantine was mandatory for ships before landing people and goods, in order to prevent the diffusion of possible infectious diseases. Furthermore, the concept of isolation appears in way earlier documents since it is mentioned in Leviticus, one of the books of the Old Testament in the Bible. Therefore, it could be hypothesized that in the VII century B.C., or perhaps even earlier, the NPI of separating lepers from the community was already widespread (Bassareo et al., 2020). Facemasks as well are not extremely recent NPIs. There are contributions from the early decades of the XX century that study the effect of gauze masks in stopping infections from droplets, expanding the knowledge on this very simple technology that was already in use in previous times (Haller & Colwell, 1918).

It is almost pointless to state that DCT has way more recent roots, but it has not been developed with the COVID-19 pandemic. As already mentioned in the previous chapter, around the 2010s, researchers at the MIT Media Lab were already investigating "whether Bluetooth could be used to trace and contain viral diffusion" (Cebrian, 2021, p. 4). Additionally, other scholars compared the measurements of contacts by DCT and users' compiled contact diaries, showing how the latter has significant problems, and a combination of the two would be desirable (Smieszek et al., 2016). A literature review contribution on DCT studies before COVID-19 found 12 relevant pieces of research, half of which assessed the effectiveness of digital contact tracing in specific contexts, while the other half developed predicting models (Anglemyer et al., 2020).

If being part of NPIs set forth by governments across the globe makes DCT a policy intervention, it is also true that it is carried out also by a technology, more precisely an app for smartphones. Since the early phase, when DCT was just considered in Europe through simulations and guidelines to its development, both scholars and public institutions considered to carry it out through a mobile phone app (eHealth Network, 2020; Ferretti et al., 2020).

Therefore, an analysis of DCT cannot ignore its double dimensions, and DCT needs to be considered both in its policy and technological dimension. Considering it as a policy implies that there is a complexity behind the

digital interface, made by community engagement and public support, planning and analysis of local contexts, trained workforces and logistics (World Health Organization, 2020a). Considering its artifact dimension, instead, requires stressing the digital side of these interventions, focusing also on its materiality, and analyzing the actors that contributed to developing and implementing the digital artifact.

2. DCT: a weak non-pharmaceutical intervention?

While a timely and detailed description of how DCT works is postponed to the next chapter, some preliminary considerations on its role during the COVID-19 pandemic are now required, also because they justify part of the research aims.

Unlike other policies/technologies, such as masks or closures, month after month into the pandemic, DCT through CTAs became progressively less relevant and considered. In the U.S., experts started doubting the impact of DCT on slowing down the rising number of cases (De La Garza, 2020). In Israel, the app was considered a failure, and technical problems afflicted the Japanese and Dutch solution, while the Australian Health Ministry declared the national app was not used in COVID outbreaks following the first ones (Chiusi, 2021). Furthermore, French rebranded its own DCT app, adding many other features since the initial contract tracing technological artifact did not work as expected (Reynaud, 2020).

Whether DCT was a failure or a success has been a relevant dilemma on which contrasting perspectives emerged. As already mentioned in the previous chapter, some empirical studies have shown how this kind of solution actually helped break some infectious chains (Rodríguez et al., 2021; Wymant et al., 2021). On the other hand, other contributions considered DCT as a failed project (White & Van Basshuysen, 2021), which is a perspective shared by none other than France's president, Emmanuel Macron, with respect to the first version of the French tracing app (Reynaud, 2020). In general, it has been shown that several analyses concluded that DCT did not perform as expected (Chiusi, 2021).

Within this complex scenario, the present contribution does not want to measure the effectiveness of this intervention, indeed the selected research approach cannot provide significant elements on this issue. Conversely, it aims at trying to understand what went wrong in the development process previously mentioned that eventually prevented DCT to become an additional central strategy against COVID-19. One of the research questions that are now presented clearly makes this aim explicit.

3. Research questions

It should be now clear that the main goal of this work is studying how digital contact tracing has been constructed as one of the weapons in the fight against the COVID-19 pandemic. If this primary intent asks to focus on the early weeks and months until the apps' rollout, analyzing this issue cannot avoid making further considerations on later phases, when the technology was actually in use. Furthermore, focusing on the development process of DCT could offer relevant insights on some of the reasons that made it not as pivotal

in the fight against the coronavirus as the months passed by. Therefore, based on these aims and goals, the two main research questions for the whole work are the following:

- What influenced the development of digital contact tracing strategies during the COVID-19 pandemic in Europe?
- Why did digital contact tracing result in a marginal non-pharmaceutical intervention in the fight against COVID-19?

The main idea that lies behind the first question is to study the complex set of relationships between human and non-human actors that brought to the implementation of the tracing technologies available to the European public. The roadmap for articulating an answer implies, first of all, studying how the debate over the design of the technology played out at the continental and national levels, with respect to the selected cases. The goal is to try to understand which have been the main actors involved in this initial phase, focusing on the interests, strategies, and values that they brought to the table while discussing the structure of the technology. Subsequently, it is key to understand how the discussed designs were transferred in the technological artifacts through the implementation process, always keeping an eye on the actors that had a major influence in setting the features of the technology. Finally, since DCT apps, and digital technologies in general, are constantly evolving artifacts, the analysis cannot exclude the using phase. The evolution of the design and implementation of these technologies does not end with the app rollout. Technological artifacts are constantly influenced by the way users interpret and employ them (Akrich & Latour, 1992). Therefore, as the last step, this research question asks for an answer that contains elements also on how users considered the apps and decided to interact with them.

Concerning the second research question, the rationale behind it has been precisely described in the prior section. Always focusing on the interplay between human and non-human actors the goal is trying to understand what put DCT aside in the comprehensive fight against COVID-19, while other interventions, such as masks and physical distancing, did not follow a similar path.

4. Methodology

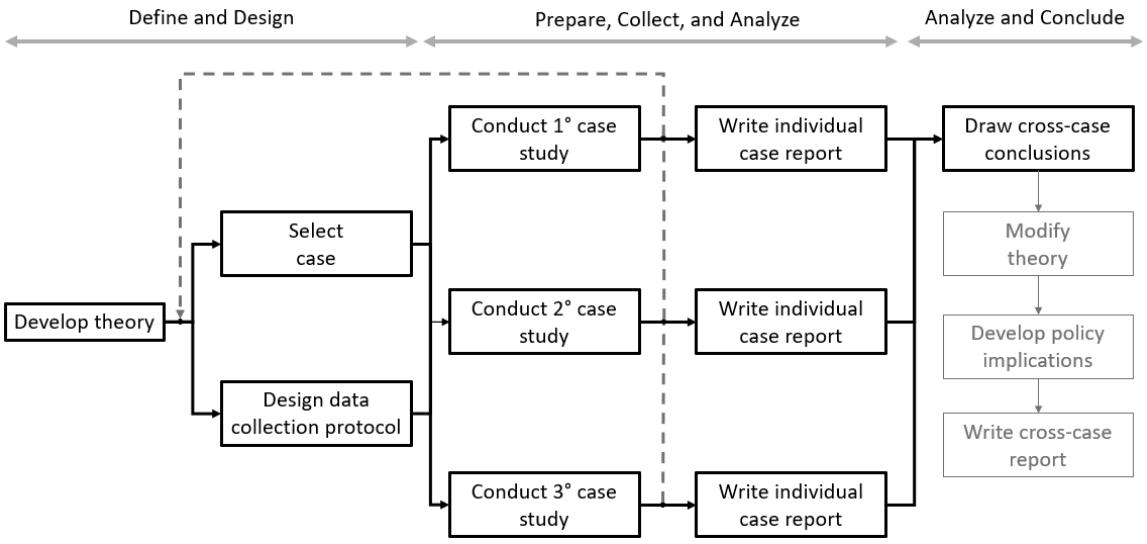
Scholars that have been reflecting on the case study approach or methodology stressed how it is quite feasible to investigate complex matters which require deep analyses in real-world settings (Harrison et al., 2017; Yin, 2018). One of the main strengths of this approach is that it can rely on a set of research techniques and methods that should contribute to in-depth analysis (Eisenhardt, 1989; Harrison et al., 2017).

The development of this contribution up to this point should have already suggested how DCT is a complex topic with many nuances, and the upcoming pages will just add on that. Furthermore, since the setting in which analyzing this policy or technology development is Europe, the elements that need to be taken into accounts are quite a lot. Therefore, the case study approach seems to offer a valuable methodological

solution to dive into the complexity of this real-world phenomenon which characterized many countries. However, connected to the valuable characteristics of the case study approach come some weaknesses that need to be carefully addressed. The main risk is to overstate some elements of the researched issue and understate others, based on the cases that are being studied (Flyvbjerg, 2011). To keep these weaknesses under control and value the strengths of this approach, the case selection is of utmost importance, along with the decision on whether one or more cases should be analyzed. As the most relevant guiding principle to select the case or cases to be studied, social science literature indicates the primacy of the research aims and related research questions (Yin, 2018). There are then numerous paths that could be followed, selecting cases based on principles of similarity or most difference, considering common or unusual cases, longitudinal and revelatory ones (Eisenhardt, 1989; Yin, 2018).

Another relevant element in the case study design that helps to maximizes the strengths and minimizes the weaknesses of this approach is the data gathering procedures (Yin, 2018). Therefore, as *Figure 1* shows, the first two steps for developing a proper case study, after having defined the theoretical framework, are selecting the cases, and defining the data gathering procedure. The upcoming pages will discuss these two elements with respect to the aims of this research, giving progressively shape to the case study design.

Figure 1 – The case study procedure



Source: elaboration from Yin, 2018

4.1 The case selection: Italy, France, and Germany

The first and main selection decision that has been made is related to a higher geographical level with respect to the actually analyzed countries. As it has already been mentioned, and it will be better argued in the upcoming chapter, DCT is a global phenomenon. Starting from Singapore, the first country that developed this kind of solution (Bay et al., 2020), it reached several parts of the world, from Australia to Bahrain, from

Ghana to Fiji, China, and many European countries (O'Neil et al., 2020). Identifying a somehow consistent geographical area in the whole globe, from which selecting the countries to study, seemed a fair and required simplification of this very complex scenario.

Therefore, Europe has been selected for three main reasons. First of all, the European Union offers a general similar regulatory, cultural, and technological framework in which several countries act with a certain share of independence. It happened for DCT as well: the EU provided some guidelines and worked towards technological integration, but countries were free to develop their own solutions (European Commission, 2020c). Having such a common and articulated framework eases the process of considering similarities and differences among cases. Then, the debate among scholars on the best approach to digital tracing solutions mainly developed in Europe, with some actors supporting a centralized approach to DCT and others a decentralized one (Vaudenay, 2020). Finally, as a more practical reason, the research field seemed more accessible even during the pandemic in European countries instead than in faraway contexts.

So, having selected the European scenario as a broad context from which choosing the cases to analyze, three main criteria have been used to make the decision.

First of all, a list of EU members states in which digital tracing solutions are available has been defined. *Table 1* shows the 21 tracing apps available in Europe in early 2022, the countries who developed them, the release date, and whether they are interoperable with other apps or not. Interoperability is an important technicality, which however does not need to be presented from a technical point of view. It simply regards the possibility for apps to talk to each other, namely whether a positive contact registered on a certain country's app results as such also on another country's app. Interoperability is possible, as it will be precisely presented in the next chapter, if the framework on which the two apps were developed is the same. Basically, the two main models that EU apps follow are the decentralized and centralized model. The first one relies more on the user's device to process data of encounters, while the centralized one does most of the work on a central database. These issues may appear as mere technical discussions, but as many of the contributions that have been presented in chapter one shows, there are never purely technical issues. As the upcoming chapter will tell, the debate on the centralized and decentralized approach, that ultimately decided whether a DCT solution is interoperable with others or not, involved many actors with different interests and values. Therefore, it is relevant to include the interoperability feature in the case selection process to have a more complete picture of DCT, considering interoperable and non-interoperable solutions.

Table 1 shows the countries ordered by the release date of their national app, highlighting those rolled out between June and July 2020. Prioritizing the apps that have been released first seems a valuable criterion for trying to capture those technologies that incorporate the debates on DCT since the beginning. For instance, analyzing how a DCT app has been implemented in a country in autumn 2020 could miss some of the early

elements of DCT strategies in Europe, since it has been probably built on successes and failures of previously developed technologies/policies.

Table 1 - DCT apps in EU members states

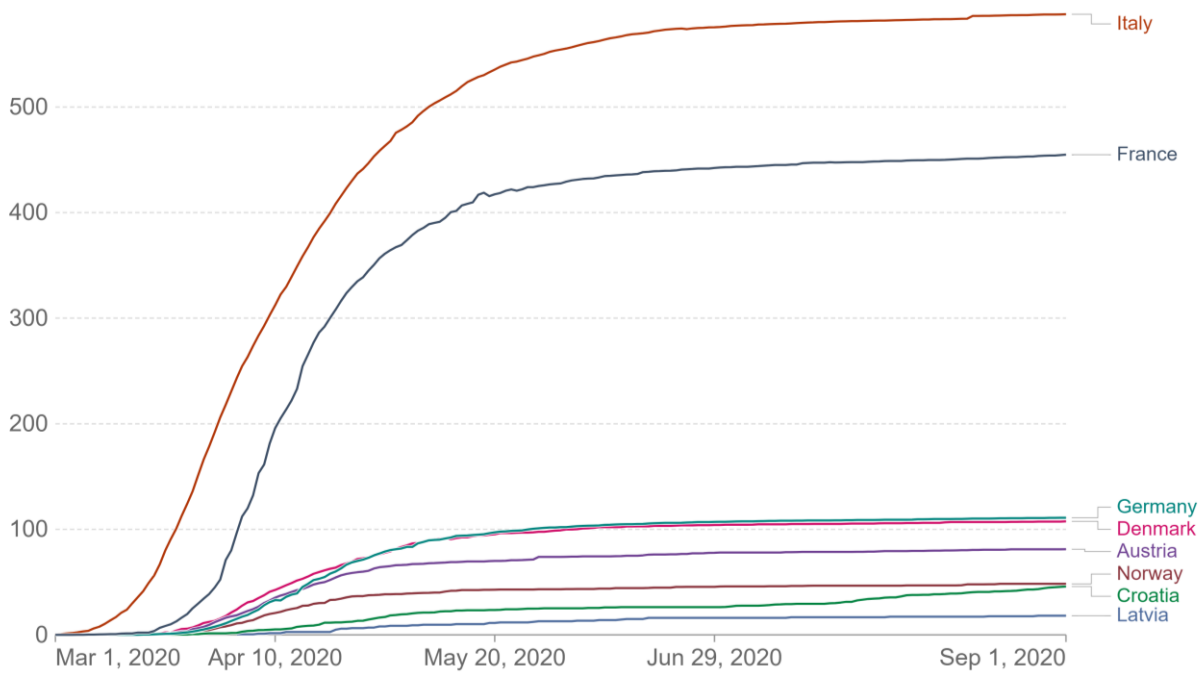
Country	App	Release date (2020)	Interoperability
Latvia	Apturi Covid	28/05	Yes
Italy	Immuni	01/06	Yes
France	TousAntiCovid	02/06	No
Austria	Stopp Corona App	25/06	Yes
Denmark	Smittestopp	25/06	Yes
Norway	Smittestopp	25/06	Yes
Croatia	Stop COVID-19	30/06	Yes
Germany	Corona-Warn-App	02/07	Yes
Ireland	COVID Tracker	15/07	Yes
Netherlands	CoronaMelder	10/08	Yes
Spain	Radar Covid	11/08	Yes
Portugal	StayAway COVID	13/08	No
Estonia	HOIA	18/08	No
Slovenia	#OstaniZdrav	18/08	Yes
Malta	COVIDAlert	28/08	Yes
Finland	Koronavilkku	31/08	Yes
Belgium	Coronalert	24/09	Yes
Poland	ProteGO Safe	13/10	Yes
Lithuania	Korona Stop LT	06/11	Yes
Cyprus	CovTracer-EN	01/12	Yes
Hungary	VirusRadar	n/a	No

Source: own elaboration on data from European Commission[2]

As a second criterion, the cumulative number of COVID-19 deaths per million people in the first six months of the pandemic has been considered for the countries that released the app earlier. *Figure 2* shows that the most affected countries have been Italy and France. In third place comes Germany, very close to the other countries.

[2] European Commission, *Mobile contact tracing apps in EU Member States*, accessed on 24/2/22, https://ec.europa.eu/info/live-work-travel-eu/coronavirus-response/travel-during-coronavirus-pandemic/mobile-contact-tracing-apps-eu-member-states_en

Figure 2 - Cumulative confirmed COVID-19 deaths per million people



Source: (Our World in Data, 2022)

The third and final principle that guided the selection process has been the population of the top countries identified with criterion number one. *Table 2* shows the selected countries from the most to the less populous ones.

Table 2 – Population on January 1, 2021

Country	App
Germany	83,155,031
France	67,439,599
Italy	59,257,566
Austria	8,932,664
Denmark	5,840,045
Norway	5,391,369
Ireland	5,006,907
Croatia	4,036,355
Latvia	1,893,223

Source: own elaboration on data from Eurostat [3]

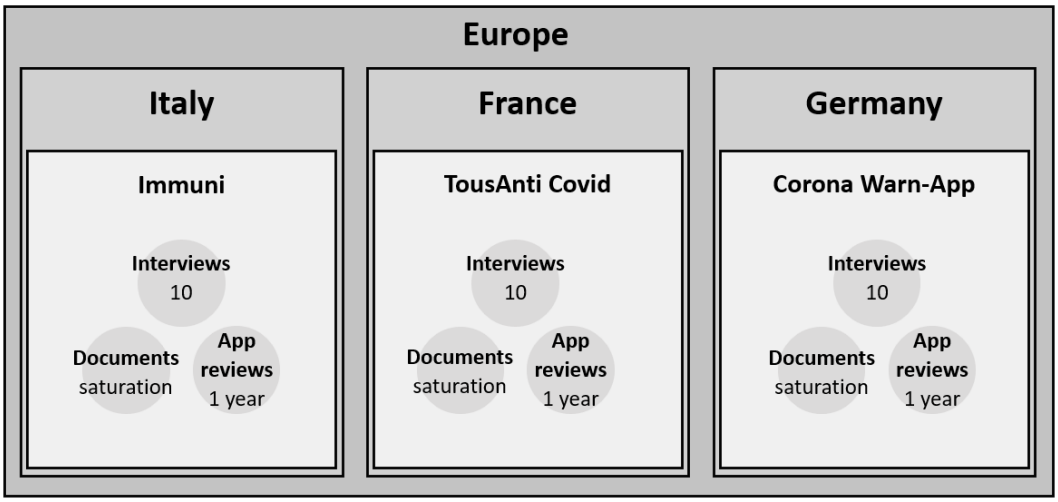
[3] Eurostat, *Population on 1 January by age and sex*, accessed on 24/2/22, https://ec.europa.eu/eurostat/databrowser/view/DEMO_PJAN$DEFAULTVIEW/default/table?lang=en

Based on these three criteria, two countries really stand out: Italy and France. They seemed two relevant cases to study DCT in Europe since they appear in the top places in all three classifications, but most importantly they have a key difference. As *Table 1* shows, Immuni, the DCT solution developed and adopted by Italy, is interoperable, while the French one is not. In other terms, the Italian app follows the decentralized approach, while TousAntiCovid follows the centralized one. As mentioned, there will be the chance to argument more on the difference between the two approaches in the upcoming chapter.

Such a decision to analyze cases that present significant differences is coherent with the literature on the case study approach that suggests that focusing on opposite types could be a valuable research strategy (Eisenhardt, 1989). Besides these two countries, a third one emerges from the classifications based on the three criteria. Furthermore, through the development of the pandemic, it emerged that this country was able to register higher download numbers for its national tracing app and the DCT app was fulfilling the aims for which it was developed (CWA Team, 2021). Therefore, Germany has been included in the analysis as well. It is an interesting additional case for studying the design and implementation processes of the other two countries where DCT has been considered a failure by people inside and outside institutions (Angius & Zorloni, 2020; Reynaud, 2020).

Therefore, the case study design for this contribution is a multiple-case design with a single unit of analysis (Yin, 2018), as pictured in *Figure 3*. The European context works as a broader framework in which the three selected countries are inserted with their respective DCT apps. *Figure 3* also anticipates the data gathering techniques that have been selected for this case study and that are now going to be presented. For each one of the techniques are indicated also additional information with respect to the quantity or time extension of the gathering process. For each one the national case the goal was to make ten interviews with relevant actors, collect official documents from institutional actors until saturation was reached, and scrape one year of users' reviews from the digital stores.

Figure 3 – The case study design (Yin, 2018)

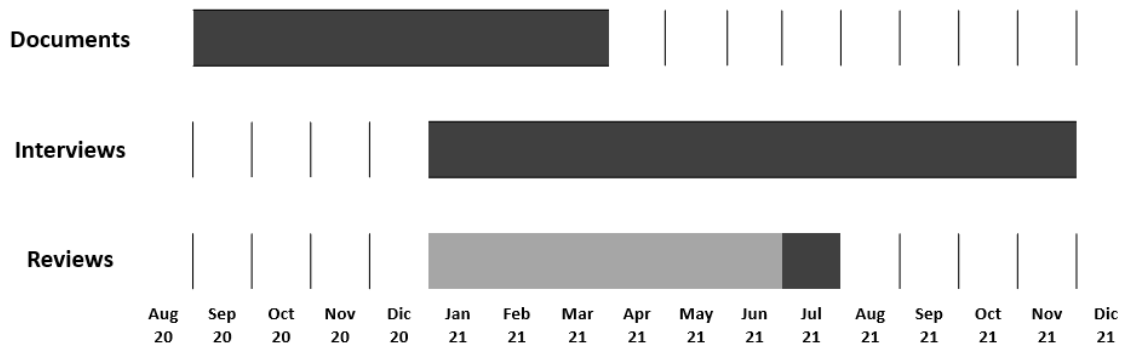


5. Data and methods

As already mentioned, one of the strengths of the case study approach is the opportunity to rely on multiple sources of evidence. Participant observations, direct observations, interviews, the study of artifacts, and document analysis are some of the empirical methods that can be employed to study the research matter (Bowen, 2009; Eisenhardt & Graebner, 2007; Harrison et al., 2017; Yin, 2018). In this contribution, three sources of information have been selected and are going to be precisely described in the upcoming sections. Official documents, semi-structured interviews with relevant actors, and users' reviews of DCT apps posted on digital stores seemed three valuable paths to reach the research aims. The rationale that brought to this decision can be summarized by the expression "follow the actors", used both in SCOT (Bijker & Law, 1992) and in ANT (Baron & Gomez, 2016) for methodological purposes. The three sources of information, as it would emerge in the dedicated sections, offer relevant and detailed perspectives on the development of DCT. Official documents contain the perspective of the more institutional actors. Through the interviews, first-hand information from a similar portion of relevant actors can be gathered as well since the target was to reach those involved in the design and implementation of DCT in the three contexts. Finally, the users' reviews add the viewpoint of an additional relevant actor in the development process of a technology. This last source of data could be useful to understand users' expressed opinions on the researched issue. It can be obtained thanks to automatized procedures that are going to be precisely presented in the upcoming pages. As official documents, users' reviews are secondary sources of data, which adds to the primary data of the interviews, constituting a valuable heterogenous base of data for the analysis.

The order in which the three techniques are presented in the upcoming pages follows the order in which they have been performed in this contribution, as pictured in *Figure 4*. The document analysis has been the first approach to the research matter, which helped structure the interviews' questions and guide the selection process of the interviewees. With respect to reviews, all the materials have been gathered monthly since January 2021, just to have a backup database should any issues arise in later months. However, the information that has been then used for the analysis was gathered at the beginning of July 2021, so the dataset covers a whole year, from June 2020 to June 2021.

Figure 4 - Timing of data collection



5.1 Document analysis

Document analysis is a very widespread and studied method in social sciences (Atkinson & Cofey, 2004; Bowen, 2009; Mackieson et al., 2019). Analyzing documents helps to provide initial useful information on the context of the research matter: they can inform the development of additional research methods, but they are also relevant sources of empirical information on the research issue in itself (Bowen, 2009). Especially when dealing with official statements by companies or governments, the data that can be retrieved by documents are often high-quality and very informative (Mackieson et al., 2019). It is important to keep in mind that such a source of information is a "social fact", namely it is a constructed artifact that incorporates values and strategies of the writers and only partially represents them. These characteristics ask for increased attention when dealing with this kind of material because it is key to have clearly pictured their characteristics and the objectives they aim to accomplish (Atkinson & Cofey, 2004).

As reported in *Table 3*, for each of the analyzed cases a set of official documents has been selected to deepen the understanding of the context around the research matter and begin considering the perspectives of different involved actors.

Table 3 - Selected documents for each analyzed case

App documentation	IT[4]	Immuni, Immuni's High-Level Description
	FR[2]	TousAntiCovid, TousAntiCovid read me
	DE[3]	Corona-Warn-App, Corona-Warn-App: Documentation
Research team & developers	IT[4]	Ministro per l'innovazione, *Relazione tecnico-giuridica sui profili connessi all'eventuale adozione di una soluzione di contact tracing per il contrasto al COVID-19* Ministro per l'innovazione*, Report sottogruppo di lavoro 6*
	FR[5]	Inria, 7 April 2020, *Inria has created its Covid-19 Mission* Inria, 18 April, 2020, *Contact tracing: an overview of the challenges Bruno Sportisse, Inria CEO* Inria, 26 April 2020, *The StopCovid project-team and the ecosystem of contributors are working together to develop a mobile contact tracing app for France* Inria, 11 May 2020, *The StopCovid project, a digital solution to contribute to the citizens' fight against the Covid19 epidemic* Inria, 12 May 2020, *The StopCovid project-team starts publishing the source code and documentation of the StopCovid application* Inria, 26 May 2020, *The StopCovid application in the hands of bug hunters* Inria, 4 July 2020, *FAQ sur les aspects techniques de l'application StopCovid*
	DE[6]	Telekom, 15 May 2020, *German government commissions SAP and Telekom with Corona warning app* Telekom, 18 May 2020, *Corona warning app development: "Publish often and early"* Telekom, 12 June 2020, *Corona-Warn-App: "Development is heating up"* SAP, 17 June 2020, *Deutsche Telekom and SAP Publish Corona Warning App After Just 50 Days of Development*
Parliament debate**s**	IT[7]	Ministro per l'innovazione, *Audizione 3 giugno 2020* Ministro per l'innovazione, *Covid-19 e innovazione tecnologica , audizione ministra Pisano alla Camera dei Deputati*
	FR[8]	Senate, 27 May 2020, *Digital innovations in the fight against the COVID-19 epidemic*
	DE[9]	Deutscher Bundestag, 7 May 2020
Privacy Authority	IT[10]	Garante per la protezione dei dati personali, *Provvedimento di autorizzazione al trattamento dei dati personali effettuato attraverso il Sistema di allerta Covid 19- App Immuni - 1° giugno 2020*
	FR[11]	CNIL, *Deliberation n ° 2020-046 of April 24 , 2020 providing an opinion on a mobile application project called " StopCovid ".*
	DE[12]	BfDI, Letter to the BMG on a legal regulation of a "Corona App"

[1]last access 17/2/22, https://github.com/immuni-app/immuni-documentation
[2]last access 17/2/22, https://gitlab.inria.fr/stopcovid19/accueil
[3]last access 17/2/22, https://github.com/corona-warn-app/cwa-documentation
[4](Ministro per l'innovazione, 2020d, 2020c)
[5]Inria, 7 April 2020, last access 3/3/22, https://www.inria.fr/en/inria-has-created-its-covid-19-mission
Inria , 18 April 2020, last access 15/06/22, https://www.inria.fr/en/contact-tracing-overview-challenges-bruno-sportisse-inria-ceo
Inria, 26 April 2020, last access 3/3/22, https://www.inria.fr/en/stopcovid
Inria, 11 May 2020, last access 3/3/22, https://www.inria.fr/en/le_projet_stopcovid
Inria, 12 May 2020, last access 3/3/22, https://www.inria.fr/en/stopcovid-source-code
Inria, 26 May 2020, last access 3/3/22, https://www.inria.fr/en/stopcovid-application-hands-bug-hunters
Inria, 4 July 2020, last access 3/3/22, https://www.inria.fr/fr/faq-sur-les-aspects-techniques-de-lapplication-stopcovid
[6]Telekom, 15 May 2020, last access 3/3/22, https://www.telekom.com/en/company/details/german-government-commissions-sap-and-telekom-with-corona-warning-app-600742
Telekom, 18 May 2020, last access 3/3/22, https://www.telekom.com/en/company/details/corona-warning-app-development-publish-often-and-early-600750
Telekom, 12 June 2020, last access 3/3/22, https://www.telekom.com/en/company/details/corona-warn-app-development-is-heating-up-601952
SAP, 17 June 2020, last access 3/3/22, https://news.sap.com/2020/06/corona-warn-app-deutsche-telekom-sap/
[7](Ministro per l'innovazione, 2020b, 2020a)
[8]last access 18/2/22, http://www.senat.fr/seances/s202005/s20200527/s20200527_mono.html#Niv1_SOM7
[9]last access 18/2/22, https://dserver.bundestag.de/btp/19/19158.pdf
[10](Garante per la protezione dei dati personali, 2020)
[11](CNIL, 2020)
[12]last access 17/2/22, https://www.bfdi.bund.de/SharedDocs/Downloads/DE/DokumenteBfDI/Stellungnahmen/2020/Schreiben-an-BMG_Corona-App-Gesetz.html

With respect to app documentation, the official materials provided by the apps' developers on the website GitHub, for the Italian and German solutions, and GitLab for the French one, have been screened and considered. These two websites are repositories where developers can share their opensource projects, uploading several information such as the scripts of the developed applications, and also gather suggestions on their work. This documentation is quite useful to have an initial broad and general firsthand understanding of the features of each project since it is official material shared by the people involved in the implementation of the DCT technologies.

Under "Research team & developers" fall the official statements on the websites of the institutions and companies that contributed to the development and implementation of the app. These materials are useful to grasp how these actors pictured their work on DCT. The documents considered in this category run from interviews with the leadership of each group to updates on the development of the apps, and FAQs on their use. The full list of selected materials is reported in *Table 3*, the rationale behind their selection was to gather the most informative materials by the institutions and companies involved in each context, especially before the apps' launch. With respect to Italy, no official communication has been released before the rollout of Immuni by those who worked on it. However, two very important reports have been written by two groups of experts created by the Italian Ministry of Innovation. The two experts' groups are part of a larger project on a data-driven strategy against COVID-19 promoted by the Innovation Ministry (Ministro per l'innovazione, 2020e). The two groups released these documents that evaluate the technical and the legal features of the DCT apps that were submitted to an Innovation Ministry's call to become the official digital tracing solution for Italy. On the other hand, all the materials for France come from Inria, the Institut national de recherche en sciences et technologies du numérique, which mainly managed the development of DCT in France. The ones from Germany come both from SAP and Deutsche Telekom, the two companies that contributed to the implementation of the technology.

Moving to the Parliament debate materials, the transcriptions of one debate on DCT at the French Senate and one debate at the Bundestag have been considered. More specifically, the May 27th, 2020, parliamentary debate on digital innovations in the fight against the COVID-19 epidemic in France, and the issue 15B on the agenda of the May 7th, 2020, parliamentary debate in Germany. The full transcriptions of the discussions between members of the Parliament and representatives from the Government offer relevant insights with respect to how DCT was framed by these actors during its developments. Both the materials have been automatically translated into English for analysis purposes. With respect to Italy, two hearings (the April 30th and the June 3rd ones) by the Ministry of Innovation have been considered since they provide interesting indications on how the digital tracing strategy was developed by the Italian Government.

Finally, the reports on the national DCT solutions by the Privacy Authorities in each country have been selected. These documents offer interesting insights on the legal side of the matter, especially the privacy one, and show how these public institutions decided to frame tracing apps.

This heterogeneous set of documents has been defined based on the different actors that participated in the process of designing and implementing DCT. The considered materials helped offer a first, but also a deep perspective on DCT. However, documentation from three additional actors needs to be included to have a more complete picture of the issue, incorporating the perspective of the EU, Apple and Google, and the research teams that developed the protocols. *Table 4* shows the documents by the three actors that have been considered relevant for enriching the analysis.

With respect to Apple and Google, the first two joint press releases, published on April 10th and May 20th, 2020, that announced the DCT technological framework have been considered since they provide useful information on the aims of the firms' initiative. Furthermore, a joint document of frequently asked questions (FAQs) has been included. From the two firms' answers emerges significant information on some of the most relevant topics related to DCT, such as the technical features of their solution, the approaches to privacy and data protection, and general guiding principles and aims.

Concerning the documentation from the EU institutional bodies, four main contributions have been included in the analysis since they provided evidence of the strategies and values that guided the EU's actions towards this issue. The Commission recommendation was the first official document released by an EU institution on DCT; it offers relevant elements to understand how tracing digital technologies has been approached and framed. The Guidance on Apps and the Common EU Toolbox are more detailed and later-published documents (just a little bit more than a week, which tells the fast pace in which this issue was being managed); through them, it is possible to better understand some of the elements of the EU's DCT strategy and rationale. Moreover, the press release on interoperability is a shorter, but still relevant document, since it covers this very important issue that has been already mentioned and will be more precisely analyzed in the next chapter.

Finally, what could be considered as the whitepapers of the three main research groups who developed the initial European DCT protocols have been considered. These documents put forward the scholars' intentions, priorities, and concerns when developing different DCT approaches. A timely, precise, and in-depth analysis of the main features of these protocols and the groups that developed them will find room in the upcoming chapter.

Table 4 – Data sources from Apple & Google, the EU, and DCT Protocols

Actors	Documents	Publication date
Apple & Google[5]	"Apple and Google partner on COVID-19 contact tracing technology"	10 April 2020
	"Exposure Notification API launches to support public health agencies"	20 April 2020
	Exposure Notifications - Frequently Asked Questions	n. a.
European Union[2]	Commission recommendation on a common Union toolbox for the use of technology	8 April 2020
	Common EU Toolbox for Member States (eHealth Network)	15 April 2020
	Guidance on Apps supporting the fight against COVID 19 pandemic in relation to data protection	17 April 2020
	Coronavirus: Commission starts testing interoperability gateway service for national contact tracing and warning apps	14 September 2020
Protocols' research teams[3]	PEPP-PT: Pan European Privacy Protecting Proximity Tracing	18 April 2020
	ROBERT: ROBust and privacy-presERving proximity Tracing	18 April 2020
	DP-3T: Decentralized Privacy-Preserving Proximity Tracing	25 May 2020

On the *corpus* of documents from both tables, inductive thematic analysis has been performed (Mackieson et al., 2019). For a detailed presentation of the data analysis approach, refer to the dedicated subsection in upcoming pages. The analysis process has been the same for documents and interviews, therefore it has been decided to describe it in a common paragraph. However, it is important to state here that an initial process of familiarization with documents preceded the realization of interviews and it also provided useful guidelines in constructing them.

5.2 Interviews with relevant actors

Interviews are among the research methods often employed when dealing with case study analysis (Eisenhardt & Graebner, 2007). This contribution relies on semi-structured interviews, which seemed a valuable strategy since they present clear guidelines to tackle the research aims but they also have a certain share of flexibility to cover unexpected topics relevant for the research (Edwards & Holland, 2013; Rubin & Rubin, 2012). More precisely, in this study semi-structured interviews with experts have been performed. Social science literature largely studied this kind of approach, arguing how experts and elites usually can offer three types of relevant knowledge to the researcher. First of all, experts have technical knowledge, namely detailed information on procedures, facts, and rules related to a specific matter. Then they have and can share process knowledge that is related to organizational features of the research matter. Finally, experts

[5] Google, 10 April 2020, https://blog.google/inside-google/company-announcements/apple-and-google-partner-covid-19-contact-tracing-technology/
Google, 20 May 2020, https://blog.google/inside-google/company-announcements/apple-google-exposure-notification-api-launches/
(Apple & Google, 2020)

[2](European Commission, 2020b, 2020a, 2020d) (eHealth Network, 2020)

[3](Inria & Fraunhofer, 2020; PEPP-PT, 2020b; Troncoso et al., 2020)

hold interpretative knowledge, meaning they have their own views on the matter they are experts in. Being able to understand the differences between these three types of knowledge is often up to the researcher's skills (Bogner et al., 2018; Döringer, 2021).

As one of the main challenges of interviewing experts and elites, the literature mentions access to the field, since it is often difficult to get in touch with these kinds of actors (Bogner et al., 2018). This specific issue has been very much remarkable in this work as well, to the point that it asked for an adaptation of the case study design. While the initial plan was to perform the same number of interviews in each analyzed country, the strategy changed while in progress, reassured by the literature that describes the possibility of an adaptive case study design (Yin, 2018). Anyway, a detailed description of the interviewing process for each country would help better frame this issue, which would ultimately be tackled at the end of the chapter.

5.2.1 Interviewing in Italy

After a first screening of the relevant documents related to DCT, an overview of the main actors involved in its design and implementation process was somehow clear for the Italian case, the first one that has been covered. Such evidence guided the selection of interviewees, which initially aimed at getting in touch with institutional actors, and later reached experts involved in the development of the tracing apps, scholars involved in the development of the general protocols, computer science scholars, and local healthcare authorities. Thanks to the contacts of one of the interviewees, an additional interview has been added later with a professional from the EU Commission that worked on DCT. *Table 5* presents all the interviews performed in Italy, divided into the just-mentioned categories, which also represent an initial raw mapping of some of the most relevant actors involved in the development of DCT in Italy. Some relevant additional players are missing because it was not possible to gather first-hand material with them, as will be later described. Furthermore, the interviewed computer science experts did not participate in the design and implementation of Immuni. However, *Table 5* starts picturing some of the main actors whose roles will be attentively considered in upcoming chapters.

For the sake of clarity, the double letters, such as N_1 + N_2, indicate that two people were present in the same video call and answered the questions.

Table 5 - Interviewees for the Italian case divided by category

Task Force	Technical Group	Interviewee A, Interviewee B
	Privacy Group	Interviewee C, Interviewee D
Protocol experts		Interviewee E, Interviewee F
Developers' teams		Interviewee G, Interviewee H, Interviewee I
Computer science experts		Interviewee L, Interviewee M
Local Healthcare Authorities		Interviewee N_1 + N_2, Interviewee N_3, Interviewee O
EU		Interviewee P

Before describing each category since relevant differences emerge, it is important to state some common features. The interviewing process in Italy run from January 2021 to July 2021. Most of the interviews have been realized through video-call tools, while *G*, *H*, and *I* have been realized via phone-call. Due to the closures and restrictions related to the coronavirus, relying on these tools was inevitable. Conversely, the interview with N_3 was face-to-face since it was realized during a visit to a healthcare authority's office, as it will be later better described. Questions were always sent in advance due to the complexity of the topic. As the literature tells, non-face-to-face interviews tend to be shorter than usual semi-structured face-to-face interviews (Bogner et al., 2018). It has been the case also in this contribution since all of them lasted from 30 to 45 minutes, once again N_3 does not follow the trend since it lasted longer.

5.2.1.1 Recruitment strategies

The recruitment largely happened via email: most of the contacts of these relevant actors were available online, while others have been obtained thanks to interpersonal contacts. Some of the interviewees, as more precisely described soon, asked not to be recorded and to keep them anonymous, due to their public exposure and the – at the time – controversial matter. Even though some interviewees did not ask for anonymity, to have a more coherent scenario it has been decided to exclude all the names from this contribution. A general example of the semi-structured interviews is reported in the *Appendix* to provide a broad understanding of the main covered issues. Of course, these guidelines have been adapted based on the interviewee's field of expertise and his or her country of origin, stressing more consistently the more relevant dimensions in each situation.

With respect to the members of the task force created by the Italian Innovation Ministry (Ministro per l'innovazione, 2020e), relatively few attempted contacts have been made via email since the goal number of interviewees was quickly reached, and just 3 messages went unanswered. Among the several actors involved in the task force, the approach to select possible interviewees initially considered the leadership of each group and then the availability of email contacts online. Two people who participated in the technical group

number 6 (Ministro per l'innovazione, 2020d) agreed to the interview, one of them asked not to be recorded. Similarly, two members of the legal group number 8 (Ministro per l'innovazione, 2020c) decided to answer the questions. Both these interviewees asked not to be recorded due to their official institutional involvement in the DCT project, also mentioning a non-disclosure agreement that they were required to sign.

The two experts related to the general digital contact tracing protocols are both Italian, despite their activity with the research group who developed one of the protocols being mainly international. Both have been contacted via email and agreed to answer the questions, while other colleagues which have been contacted as well did not reply to the messages. However, the two interviews guaranteed an adequate share of first-hand information on the tracing protocols.

The people involved in the apps' development have been reached thanks to interpersonal contacts. Interviewee *G* was in the team that presented Immuni to the Innovation Ministry's call, while interviewees *H* and *I* were part of the team of the other shortlisted app (Ministro per l'innovazione, 2020d), that ultimately was not selected by the Italian Government.

An outside perspective on the DCT project has been included in the analysis by interviewing two computer science scholars from the Università degli Studi di Milano – Bicocca. Despite not having directly taken part in its development, the two scholars provided useful technical viewpoints on DCT, discussing its design, its technical features, and its implementation.

Getting in touch with local healthcare authorities has been quite complicated. Several attempted contacts have been made with local healthcare authorities from one northern Italian region, Lombardia, reaching six out of the eight authorities who work in the region. Then the authorities from a central Italy region, namely Emilia-Romagna, have been contacted, reaching out to seven out of the eight based over there. Three different institutions answered to the first contact among those located in the North, but just one at the end agreed on the interview. First of all, two members of the leadership in the institution (N_1 and N_2) answered to questions via video-call, but then they suggested to visit their facility to see their COVID-19 tracing system at work. Therefore, N_3, a professional working on contact tracing, answered to some questions, yet not recorded, and presented the tracing tools used by the local healthcare authority.
With respect to the central Italy authority, one standard video-call interview has been realized. These regions have been selected since, as shown in *Table 6*, they registered the highest number of positive contacts recorded by the app. The timeframe considered lasts from the app launch in June 2020 to July 2021, which has been the same for the analysis of the users' reviews, as it will be better explained later.

Table 6 - Cumulative number of positive Immuni users June 2020 - June 2021

Region	Positive users	Region	Positive users
Emilia-Romagna	4113	Puglia	494
Lombardia	3623	Friuli	415
Toscana	2297	Sardegna	231
Lazio	2256	Valle d'Aosta	184
Piemonte	1219	P.A. Trento	182
Sicilia	1175	Basilicata	155
Abruzzo	1101	Umbria	115
Marche	775	P.A. Bolzano	94
Veneto	661	Molise	-7
Campania	597	Calabria	-14
Liguria	563	Estero	-14

Source: own elaboration from Immuni data on GitHub[6]

Finally, *Interviewee P* has been engaged thanks to *Interviewee H*. The interview was not recorded since, due to his institutional exposition as a professional working also on DCT for the EU Commission, the interviewee asked so. Furthermore, the interviewee was very busy and could not dedicate too much time to answering the questions. However interesting elements emerged, and an additional perspective to DCT was added.

One relevant missing perspective that would have been interesting is the one by Apple and Google. Both the Italian divisions of the companies have been contacted. Apple never answered, while Google said that no additional relevant information could be provided besides what was already written in official statements. Despite not having first-hand information, the perspective of Apple and Google has been included in the analysis through their official statements and the materials that have been previously described.

The difficulties in getting in touch with Apple and Google offer the chance to stress once again some of the issues of recruiting interviewees and conducting interviews in Italy. As already mentioned, the other group of relevant actors that required many missed attempts before succeeding in gathering useful materials has been local healthcare authorities. The fact that the pressure of the pandemic has always been quite strong on these actors could have probably played the main role in getting no answer. Probably, those working in the healthcare authorities were too busy managing the pandemic to undergo academic research interviews. At the same time, it should be probably excluded that the low response rate came from the arguably highly controversial topic of the research. The members of the two authorities that answered the questions did not

[6] Immuni GitHub, last accessed 8/3/22, https://github.com/immuni-app/immuni-dashboard-data/blob/master/dati/andamento-mensile-dati-regionali.csv

show significant concerns when talking about Immuni, even when mentioning its big problems. On the other hand, as already said, some concerns due to the high political relevance of the matter have been shown by the interviewees who participated in the national task force. These concerns ultimately may have brought the interviewees to not share some information, also because some of them mentioned a non-disclosure agreement. Finally, the low time availability of some of the interviewees has been an additional issue to manage. However, all the interviews with the relevant actors reported in *Table 6*, despite being sometimes short such as for interviewees *G* and *P*, offered relevant perspectives on the research issue.

5.2.2 Interviewing in France and Germany

The recruitment of interviewees in France and Germany experienced even more significant problems than in the Italian case. Many attempts have been made to relevant actors involved in the development and implementation of DCT in the two countries, but most of them went unanswered. The main reason could be spotted in the controversiality of DCT, especially in France, where some of the interviewees asked not to be recorded, arguably for the same reason. The language could have been an obstacle as well since both the first contact and the interviews were performed in English. Anyway, the recruitment and the realization of the actual interviews lasted from April 2021 to November 2021. All the 11 companies involved in the implementation of the French app have been contacted, as well as six French scholars that covered DCT with their contributions and the experts from Inria who designed the app. With respect to Germany, 14 scholars involved at different extents in the Corona-Warn-App project have been reached, along with two additional scholars that wrote about the German app and the companies that contributed to its development. Out of these many attempted contacts, a reduced number of people answered and agreed to the interview as pictured in *Table 7*.

Table 7 - Semi-structured interviews for the French and German cases

France	**Research Teams and developers**	Inria
	Computer science experts	Interviewee Q, Interviewee R, Interviewee S
Germany	**Research Teams and developers**	RKI, SAP (T_1 + T_2)
	Computer science experts	Interviewee U, Interviewee V_1 + V_2

Unlike in *Table 5*, here not all the interviewees have been named with letters. While the anonymity of the spokesperson is granted, it seemed useful for the development of this work to report the name of the institutions from which it was possible to gather first-hand information. Despite having a reduced number of interviews, the most relevant perspectives for the two cases were gathered. Regarding the CoronaWarnApp, a representative from the Robert Koch Institute (RKI), the main public institution that managed DCT in Germany, and two development architects from the SAP open-source team, one of the two companies that

developed the app, were interviewed. With respect to France, it was possible to gather information from the team that developed and implemented the app at Inria, but they only agreed to provide written answers. Regarding computer science experts, just *U* was directly involved in designing DCT, while the others simply studied it, but were anyway able to offer interesting additional perspectives on it.

Further conversations have been made on the issue with a French STS scholar and an email exchange happened with the Fraunhofer Institute, a German institution involved in DCT both in Germany and France, as well as a conversation with a German scholar who studied DCT. However no significant useful information for this research emerged, therefore it has been decided to exclude them from *Table 7* and the analysis. Once again, the double letters, such as T_1 + T_2, indicate that two people were present in the same video call and answered the questions.

As an essential step before data analysis, all the recordings of interviews have been transcribed.

5.2.3 Data analysis of documents and interviews

Thematic analysis seemed the most proper analytical approach to tackle the research questions of this contribution for three main reasons. On the one hand, the literature has been showing how thematic analysis in a proper approach to identify recurring patterns and repeating ideas across the data set (Braun & Clarke, 2006; Vaismoradi et al., 2016). Such characteristic is coherent with the aim of identifying values, strategies and interests of different actors that contributed shaping the development of DCT.

Furthermore, thematic analysis is a proper method for analyzing different set of data that have been gathered in different situation, different times, and with different techniques, which contribute to increasing the complexity of the textual materials (Alhojailan & Ibrahim, 2012; Guest et al., 2014). With respect to this work, the different data gathering context are quite clear. Just to make an example, most of the interviews, as well as the documents, focus on a specific time that is the design phase of the DCT, lasting from March 2020 to June 2020. Conversely, users' reviews datasets, as it will be soon presented, cover a whole year, from the app launches until June 2021.

Finally, the research design asked that the data analysis followed the data gathering process, since having a complete and heterogeneous data base to undergo analysis seemed a more linear process. Therefore, another plausible analytical approach, namely Grounded Theory, was not that feasible since it requires simultaneity of the two phases (Thornberg & Charmaz, 2014). As already mentioned, and as it will be soon described, a preliminary analysis of documents informed the structuring of interviews. Furthermore, as shown in the next section, evidence from these two sources of data supported the analysis of reviews. However, the more articulated data analysis happened when the data gathering was concluded for each of the three sources. Therefore, the requirements for a proper Grounded Theory approach were not available. At a similar extent, content analysis did not seem a valuable solution with respect to the research aims and the related empirical materials. Despite having useful features such as the extractions of most meaningful

parts of analyzed texts, to reduce and simplify data (Schreier, 2013), it did not seem as proper as thematic analysis to tackle such a complex and heterogeneous set of data (Guest et al., 2014). As it will be shown towards the end of the chapter, themes selection for each one of the three different data sources opens interesting opportunities for further and secondary analysis on most recurring themes. Comparing the most recurring themes iteratively offers the chance to answer the research questions in a more articulated way.

From a practical point of view, the data analysis procedure that has been followed largely relied on Braun and Clarke's (2006) contribution that set relevant guidelines when conducting thematic analysis.

First of all, a long process of familiarization with data has been carried out. As already mentioned, the selected documents were the first materials that underwent this procedure. During this initial phase, all the documents were screened and read, highlighting some initial most relevant topics, issues, and ideas. This process contributed to shaping a general understanding of the researched matter, the main actors involved and the dynamics that characterized them. Furthermore, thanks to this preliminary document analysis, it was possible to structure better interviews questions and make them more coherent with the research aims. Once the semi-structured interviews' materials have been gathered, the just-described process that has been conducted on documents was repeated on the interviews' transcripts. The goal was the same: familiarizing with data and gathering some general ideas on the most relevant discussed topics and issues.

Subsequently, both the documents and the interviews' transcripts underwent the coding process. As already stated at the beginning of the chapter, inductivism guided the analysis. All the materials were precisely considered, trying to identify relevant features within the data. As scholars who employ thematic analysis show, coding is an iterative process that asks to go back and forward on different materials to find the best categorizations (Fay, 2011; Nowell et al., 2017). That is exactly what has been done on the gathered materials in order to place chunks of text in new categories or existing ones, and also evaluate whether some changes should be done to the categories themselves. To carry out this whole process, the software NVivo 12 was employed.

If the familiarization with documents data and interviews data happened in two different moments, with the first preceding the second for the reasons that have been explained, the analysis processes of coding and themes generation were conducted simultaneously.

Even though the data analysis strategy was the same, it has been decided to create two separate codebooks, one for the analysis of documents and one for the analysis of interviews. By doing so, it was possible to focus on developing more specific coding, valuing the different nature of the two types of texts. Of course, as it emerged from the initial analysis of documents that informed the structuring of interviews, the two analyses kept "talking" one another.

After having coded all the materials, all the relevant data have been reconducted to potential themes. This process has been realized in each one of the two codebooks, looking for similarities and differences between

the two sources of information. As happened with the coding, themes' definition has been an iterative process that regarded also constant reviewing of the themes themselves and the definition of their names and features (Braun & Clarke, 2006). This last process was carried out on NVivo 12 as well, which also offers useful tools for visualizing how the different codes have been grouped into themes. The two analyses, with related codebook and themes, have then been merged into a common file to continue and ease the confronting and comparing activity between themes as it will be later presented.

5.3 App's reviews in digital stores

The third and last research method is a less conventional data collection procedure, and it involves a less-known type of data compared to the previous two. Analyzing the reviews that users posted online on the digital stores can be considered an approach part of the broad domain of digital methods. The US scholar Richard Rodgers sketched the main elements of this approach in a 2009 contribution. More than a decade ago, the author reflected on the ontological stance of the constantly growing virtual world, recognizing that a distinction between phenomena happening offline and online did not seem reasonable anymore. Rogers also defined a clear principle to guide epistemological reflection in virtual environments: follow the medium. This easy-to-remember expression asks the researcher to rely on what the media he or she is studying already provide, with respect to the type of information and the way it is presented (Rogers, 2009).

Through the years the influence of the virtual world and digital data has been growing in social science, driving the scholars' attention to many media, topics, and research techniques (Flick, 2018a; Lindgren, 2018). Scholars have been reflecting on the type of information and data that can be obtained online for research aims, arguing how the Web is an enormous ensemble of data, in which virtual environments such as social media open up unprecedented options to study culture and social relations (Weltevrede, 2016). However, virtual settings do not provide "raw" research material. Just by the fact of being online, information underwent some selection processes that applied some categories, views, and values to it (Marres & Weltevrede, 2013; Weltevrede, 2016). Therefore scraping data from the Web, namely downloading content for later analyses, could already be considered as a first step into the analysis, and not just information gathering (Marres & Weltevrede, 2013). Furthermore, data should not even be considered "raw" before they get scraped because digital environments are not neutral spaces due to the influence of the actors that scripted them, who usually designed and implemented them for different aims with respect to the researcher's ones (Caliandro & Gandini, 2019).

Among the many research approaches to the digital environments (Caliandro & Gandini, 2017), analyzing users' app reviews has become a quite developed one (M. Cheng & Jin, 2019; Hoon et al., 2012; Vu et al., 2015; Zečević et al., 2021). Scholars have been showing how reviews, and the rating associated with them, is informative content to understand users' view (Hoon et al., 2012; Vu et al., 2015). The reviews posted online are considered a reliable representation of how users experience and communicate a certain product or

service, providing useful information also to those who are interested in researching the matter (M. Cheng & Jin, 2019). The interest in researching how users experience and communicate the app is shared also by this contribution, which wants to consider DCT apps' reviews to understand how users framed these technologies and what are their expressed opinions.

Of course, this research method has some weaknesses. As literature shows, reviewers of an app are just a portion of the broader group of users, who are often influenced by other reviewers' comments and have specific sociodemographic traits (Zečević et al., 2021), which however do not play a significant role when dealing with digital data (Caliandro & Gandini, 2019). When researching through digital methods, most of the time a single user cannot be reconducted to specific sociodemographic traits. His or her main characteristic would be being part of a group of people that uses a certain app and wanted to express an opinion on it (*ibidem*). Therefore, most discussed topics in reviews cannot be automatically considered as most discussed topics of the broader group of users (Zečević et al., 2021).

Furthermore, strictly related to this work, users of the DCT apps are not a fully representative group of people involved in DCT either. Recalling the distinction between DCT as policy or technology introduced at the beginning of the chapter, DCT as a technology strongly involves users, namely people who decided to download the app; DCT as policy more broadly involves citizens of a country in which the Government has decided to adopt a DCT strategy. It is really important to make this distinction explicit. It is furthermore important to keep in mind that, when analyzing reviews, the obtained results are referred to elements related to a non-representative portion of people that are using DCT technologies, which are again a non-representative portion of people involved in a DCT policy.

When dealing with digital data, ethics is another dimension that needs to be considered attentively. It is a highly debated and discussed topic in the literature, where the broad guiding principles seem to be the minimization of harms and the maximization of benefits for those who are indirectly or directly involved in the research (Tiidenberg, 2018). When dealing with digital data, it is often difficult to detail more these two principles since every single contribution may have distinctive features that makes it similar to others only until a certain extent (*ibidem*). However, some more specific guidelines are worth mentioning also with respect to this work. When dealing with online data one of the main concerns is the privacy of the users, which is an issues particularly relevant when engaging with social media (Tiidenberg, 2018). With respect to this issue, arguably the main sources of digital data, namely social media, are often considered as public spaces, a feature that authorizes the researcher to deal with the data that can be extracted from there (*ibidem*). The Google Play Store, the online environment from which the digital data for this contribution has been scraped, is not fully comparable to social media, not having therefore some features that make it ethically problematic. First of all, users' generated content is publicly available without any restriction. Then, the content posted by the users is obtained from the public page of the app and not from their personal page. Moreover, as some contributions dealing with reviews posted online argue (M. Cheng & Jin, 2019), this

material does not qualify as high sensitive content that raise major ethical concerns.
Another key element involved when dealing with digital data, or data in general, is anonymity of the subject (Tiidenberg, 2018). As *Figure 5* will soon show, the ID number and the username of the authors of the reviews are downloaded when running the scraping script. However, these two pieces of information, as well as others, are deleted and not included in the final databases that undergo the analysis, minimizing the information just to the contents of the reviews and other non-controversial elements that will be shortly introduced.

With strengths and weaknesses of this approach clearly stated, it is time to take into considerations how the analysis of users' reviews has been crafted.
A custom scraping code has been scripted following the guidelines of a google-play-scraper available online[7]. The code, whose Italian version is fully reported in the *Appendix* as an example, enables to download all the reviews posted for a selected app on the Google Play Store. Unfortunately, with a similar code, only the last 500 posted reviews can be downloaded from the Apple Store. Therefore, it has been decided to include in the analysis just the reviews from the Google Play Store, since a more complete and coherent database could be created. Some authors experienced similar technical problems in accessing all the reviews on the Apple Store (Hoon et al., 2012), and other analyses have been carried out on datasets just from the Google Play Store as well (Zečević et al., 2021). Furthermore, using the reviews just from this store should not create a significant distortion of the smartphone users' population due to penetration of Google's devices. The share of the devices operating the Google service Android is the large majority in all the three analyzed contexts, reaching almost 75% in Italy, 69% in France, and 70% in Germany (Statcounter, 2022).
The considered timeframe for each app runs from its launch, which happened at the beginning of June 2020, and it is more precisely reported in *Table 1* at the beginning of the chapter, to the beginning of July 2021. It has been decided to limit the timeframe this way for two main reasons. First of all, during summer 2021, all three apps began including the vaccination certificate's download among their features, therefore some of the reviews started covering this issue as well, which does not fall among the covered topics of this research. Then, how *Table 8* shows, the number of reviews for each case is already quite significant after almost a year from the rollout.

Table 8 - Number of reviews on Google Play Store from June 2020 to July 2021

	Google Play Store Reviews
Italia	24270
Francia	35094
Germania	61791

[7] Google-play-scraper, last accessed August 2021, https://www.npmjs.com/package/google-play-scraper

Each one of the scraped reviews appeared as pictured in *Figure 5*. Many of the information scraped is not useful and the data are not properly organized.

Figure 5 - Example of a scraped review


```
"id": [redacted],
"userName": [redacted],
"userImage": [redacted],
"date": "2021-04-30T06:57:31.533Z",
"score": 1,
"scoreText": "1",
"url": [redacted]
"title": null,
"text": "Non sono riuscito ad attivare la mia positività, perché il medico di base non può, io da solo non potevo e le asl (unici che potevano) non rispondevano al telefono.",
"replyDate": null,
"replyText": null,
"version": null,
"thumbsUp": 0,
"criterias": []
```


Therefore, a new database has been created in Excel, including just the following variables for each review:

- "date": when the review was posted
- "score": expressed rating to the app, from one to five
- "text": the content of the review
- "thumbsUp": likes to the review

5.3.1 Data analysis of users' reviews

Python was chosen as a tool for data analysis as well since academic contributions show its effectiveness for these kinds of research aims (Brooker, 2019; Zečević et al., 2021). The first step of the analysis, which has been repeated for all the three datasets of reviews, has been data cleaning. Several scholars described their data cleaning procedures to prepare the dataset for further analysis, offering interesting suggestions with respect to the best approach to use (Gharatkar et al., 2017; Guzman & Maalej, 2014; Hatamian et al., 2019). A very standard one has been scripted for this analysis, basically cleaning the dataset of all the punctuation and stop words, such as "and", "the", and "I", of course in the native language of each one of the databases.

Furthermore, all the capital letters have been removed and each string of text was divided in singular words. Finally, the lemmatization was applied to the different words, meaning that words with the same roots were reconducted to a common word (e.g.: "houses" and "housing" are considered as "house"). It is important to point out how this data cleaning procedure is mandatory to prepare the data to Natural Language Processing (NPL) techniques which can help to have a broad understanding of a large amount of data. To have the just-mentioned broad understanding of the three large datasets, the N-gram technique has been applied (Zečević et al., 2021). N-grams extraction basically implies getting the most recurring groups of words in the whole dataset. For this contribution, pairs and groups of three words have been extracted. Additional crossing with available data has been performed, considering the period in which each group of words appeared, and the

ratings associated with it.

For each one of the three cases, the top 20 recurring trigrams and the top 30 recurring bigrams have been selected and manually grouped in categories based on their content (e.g.: "Technical aspects", “Useful app”, “Useless app”)

Scholars doing NPL usually rely on additional techniques, especially topic modeling, which automatically groups most recurring words into coherent groups, giving the researcher the chance to interpret and name the groups of most popular topics (Hatamian et al., 2019; Wang et al., 2018; Zečević et al., 2021). Since the analysis needs to deal with non-English data from three different languages, it has been decided not to apply such techniques due to the high risk of data inconsistency. Furthermore, the N-grams analysis offers a sufficient level of initial understanding of most recurring topics and helps to get a broad understanding of the database. The analysis script can be found in the *Appendix* for more detailed scrutiny.

There is no need to develop additional NLP also because a further step in the reviews analysis is performed. A selection of reviews is analyzed manually through thematic analysis. Similar qualitative procedures are well documented in digital methods literature (Caliandro & Gandini, 2019). Selecting a group of reviews seemed necessary since it is infeasible to manually analyze more than 100 thousand users’ reviews. All the reviews have been ordered based on the number of likes they received. Then, the 100 most-liked reviews for each of the three countries were selected and manually analyzed.

Before undergoing the manual analysis all the selected reviews have been translated into English and uploaded on the software NVivo 12.

The analyzing process followed the one previously described for documents and interviews, relying on the literature that describes manual analysis on text data digitally produced and collected (Caliandro & Gandini, 2019). The analysis process started with familiarization with data to grasp the general topics of the considered contents. Unlike the previous analyses on documents and interviews, the general understanding of the research matter and most relevant issues was higher in the eyes of the researcher. An inductive approach guided the analysis anyway, but it must be stated that some of the evidence of the previous analyses contributed guiding the manual inquiry, especially with respect to most relevant actors and most discussed issues related to DCT. However, no pre-developed codebook was employed. Once the reviews had been properly coded through an iterative process, the different categories were reconducted to more general and comprehensive themes (Braun & Clarke, 2006).

5.4 Triangulating approaches toward a comprehensive analysis

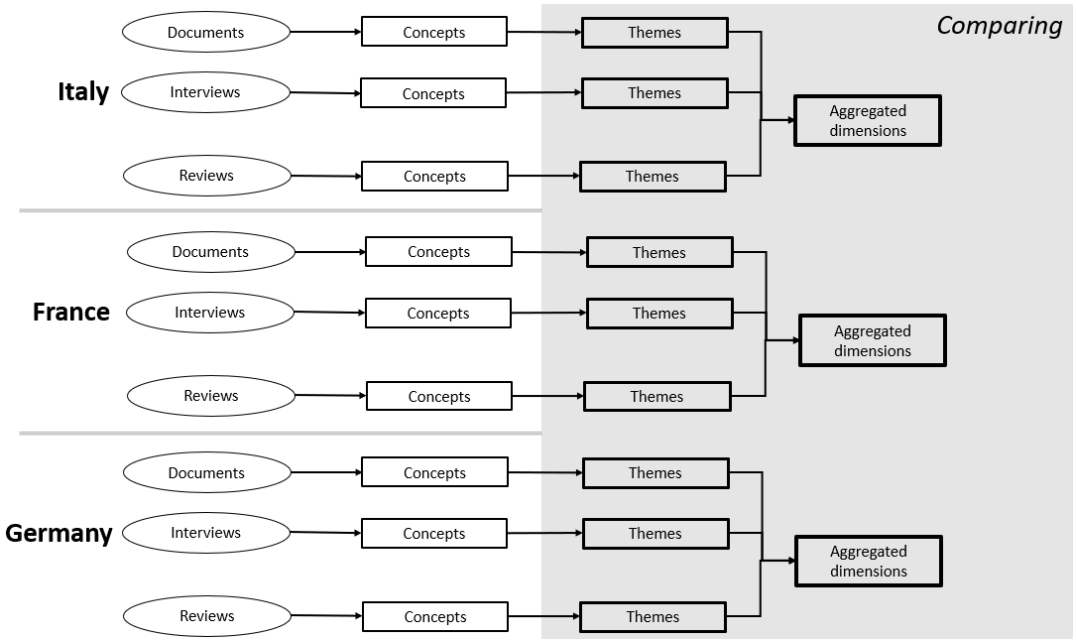
The research design presented so far strongly incorporates elements and features of a largely discussed topic in the literature that has yet to be mentioned. Right after having introduced the research questions, this chapter has been describing different possible solutions to try to reach the most adequate and comprehensive answers to these research aims. The heterogeneity in the selected cases, in the

methodological approaches (Bowen, 2009; Leech & Onwuegbuzie, 2007), in the empirical materials (Denzin, 2012), and in the target actors (Flick, 2018b) converges towards tackling the research problems through connecting the different elements, more precisely by triangulating them. Especially when complex issues are involved, relying on the triangulation of multiple paths to try to reach answers to the research questions is a valuable solution (Flick, 2018b; Turner & Turner, 2009). Triangulating different research methods, target subjects, and empirical materials also contributes to reducing the bias connected to the singular approaches, and more in general it reduces some of the well-known biases of social science analysis, namely the research bias and the respondent bias (Bowen, 2009; Flick, 2018b).

With respect to this research, multiple case studies have been selected to try to understand how DCT has been designed and implemented in Europe. Furthermore, as *Tables 5* and *6* showed, several actors have been included in the analysis; to them need to be added the apps' users and non-human actors, as will be better presented in the upcoming chapter. Such a large spectrum of actors offers interesting perspectives always oriented toward tackling the research problems. Finally, different research methods, which generated diverse empirical materials, have been employed to enlarge even more the heterogeneity of the possible paths to reach the research aims.

However, such a complex research design needs to converge towards more simple elements that can actually be informative on the research issues with respect to the analysis of gathered materials. So far, the approach on the documents and interviews data and the analysis on users' reviews have been presented separately. To find a common analytical ground between these elements, the approach designed by Gioia and colleagues (2013) offers extremely valuable guidelines. The authors developed a three-level analytical strategy with the aim of making a qualitative analysis procedure more rigorous. Building on their contribution, *Figure 6* shows the process that the analysis followed after having identified the themes for documents data, interviews data, and the reviews' one. The following step concerns working on the themes to see whether more general concepts that help describing the observed phenomena can be identified, defining therefore aggregated dimensions (Gioia et al., 2013). As a last step in the analysis, the aggregated dimensions that have been defined for each one of the selected cases are compared between themselves to try to finally reach the research aims. Whether more granular and detailed elements should be needed, the comparison between the cases would also involve the level of themes.

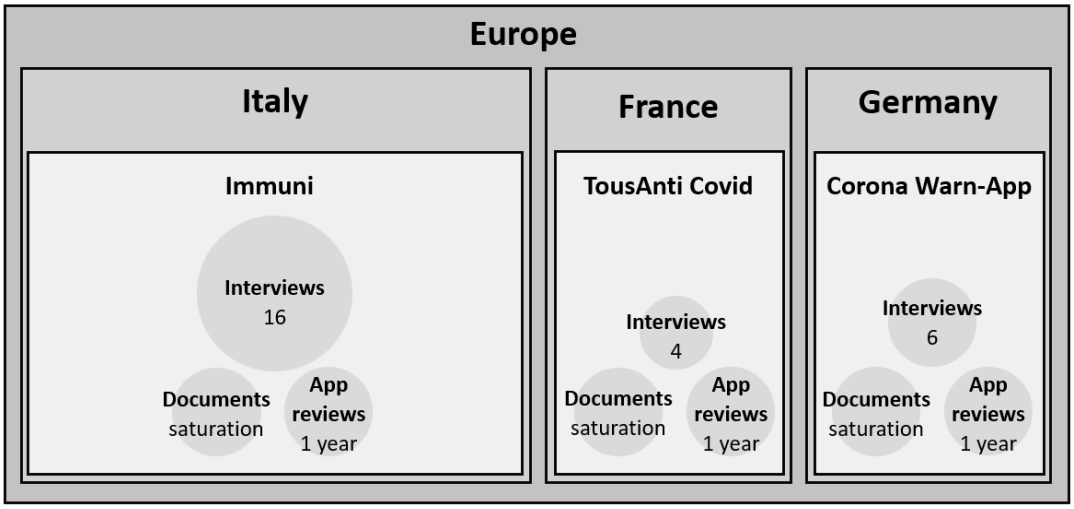
Figure 6 – Procedure of data analysis



6. Restructuring the case study design

As already mentioned in previous pages, the final case-study design underwent some changes with respect to what was initially planned before entering the field. The main reason that led to this intervention can be spotted in the experienced issues in gathering a significant number of interviews from relevant actors for the French and German cases. The possible causes of such a lack of participation have been already described, what is now required is to adapt the case-study design that was initially pictured as an equal comparison between cases. Adapting the case-study design is not an uncommon procedure when doing this kind of research, indeed it is a quite common step in multiple-case studies. Going back to *Figure 1* at the beginning of the chapter, the grey dotted line shows that, after having conducted the information gathering for each one of the considered cases, it could happen that the design of the study requires some revisions (Yin, 2018). That is what happened for this work as well. Due to the empirical material that it was possible to gather, mainly regarding semi-structured interviews, the Italian case has become the main focus of the analysis, while French and Germany move to a more ancillary, yet pivotal, role in the process of understanding how DCT has been designed and implemented in Europe. Therefore, the case study designed for this contribution, as introduced in *Figure 2*, is more precisely represented by *Figure 7*. The Italian case is the main source of information when studying DCT. France and Germany work as secondary cases. They provide key information to the broad understanding of the socio-technical phenomenon, despite not being equally comparable to Italy due to the available empirical material.

Figure 7 - The adapted case study design



The procedure set forward by Robert Yin (2018), and pictured in *Figure 1*, quite clearly shows the next steps for the development of the present contribution as well. In the following pages, each one of the cases is going to be analyzed in an individual chapter. The data emerging from the document analysis, the semi-structured interviews, and the analysis of reviews for the Italian, French, and German DCT solutions is going to be presented, after having undergone the analytical steps described in previous sections. These three chapters are then followed by an additional one that tries to draw cross-case conclusions that would ultimately answer the research questions that opened this chapter. However, before entering the analysis of each one of these cases, it is important to focus more precisely on the main characteristics of DCT, considering how it was designed, implemented, and used during the COVID-19 pandemic.

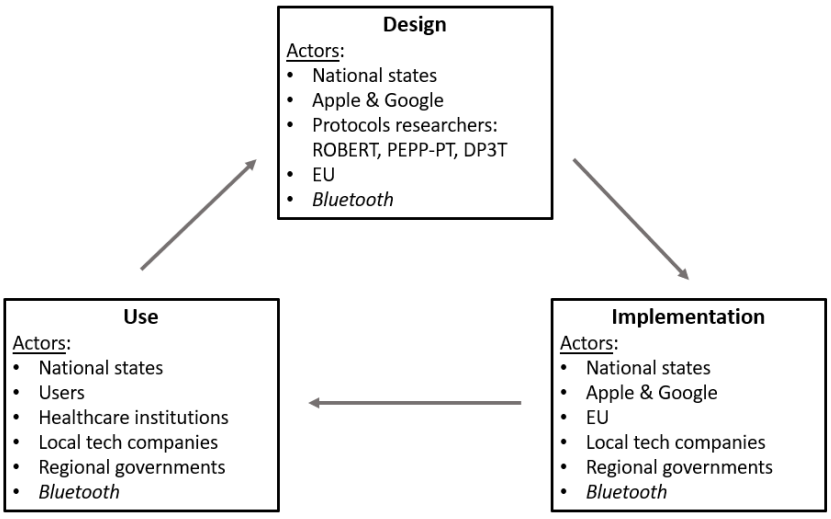
Chapter 4 – DCT during the COVID-19 pandemic

This chapter finally dives into the many nuances of DCT during the COVID-19 pandemic. As already mentioned in the previous pages, a digital approach to contact tracing emerged as a possible solution when the number of COVID-19 patients grew to the point that it overwhelmed the standard tracing procedures (Ferretti et al., 2020). The upcoming paragraph provides a timely description of how DCT works, focusing on the two main approaches that have been developed to implement it in Europe, namely the centralized model and the decentralized one.

Then, the chapter moves toward considering how DCT has been designed, implemented, and used in Europe. As the SCOT tradition suggests, to better understand the development of a technology, a strong focus on actors is required (Pinch & Bijker, 1984). Many scholars stressed that technology's characteristics, uses, and meanings are defined by the relevant actors that are involved in its process of construction (Bijker and Pinch, 2009; Humphreys, 2005; Klein and Kleinman, 2002; Williams and Edge, 1996). As *Figure 1* shows, many actors participated in the three main phases of DCT. This chapter provides an analysis of the three main actors who contributed to the development of DCT: the experts involved in the definition of protocols, the public institutions, both at the national and the EU level, and Apple and Google. An additional non-human actor, that is Bluetooth, is than attentively considered. The role of other actors, such as local tech companies or local healthcare authorities, will be analyzed in the chapters dedicated to each case study. With respect to the use phase, some relevant preliminary considerations on the role of users will be presented in this chapter, but more nationally focused contributions will be developed later as well.

Finally, to conclude the chapter, a brief but informative overview of how DCT has been implemented outside Europe will follow, focusing on some interesting cases to have a more complete picture of this issue.

Figure 1 – Different phases of DCT development and main involved actors

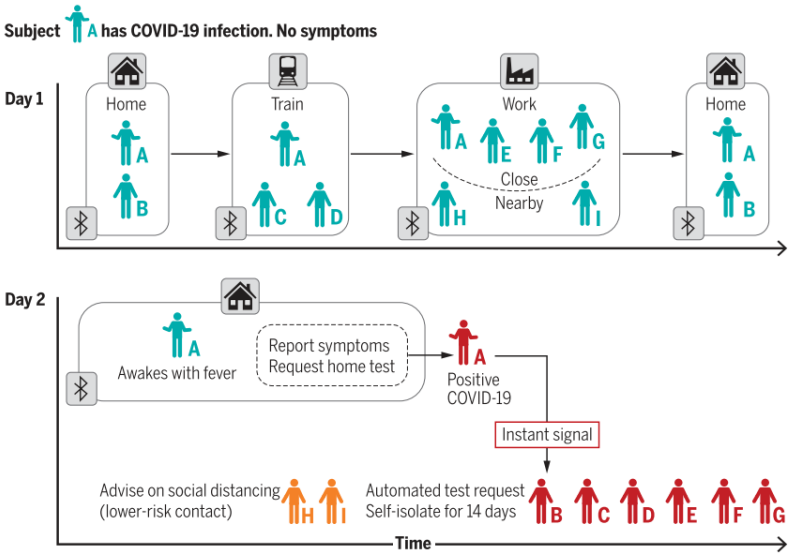


1. How DCT works in Europe

It has already been stressed how DCT did not emerge with the COVID-19 pandemic, scholars have been researching on it and testing different solutions prior to the early months of 2020 (Cebrian, 2021; Smieszek et al., 2016). However, with respect to the coronavirus pandemic, a group of scholars, guided by Luca Ferretti (2020), was among the first who published on this issue, providing a clear explanation of how digital tracing could work from a general point of view.

As pictured in *Figure 2*, let us suppose that each person owns a smartphone with a contact tracing app installed that can communicate with other smartphones via Bluetooth. On a regular day, person A wakes up at home, which s/he shares with person B. In the morning s/he reaches the workplace by train, spending quite some time on it, in close contact with people s/he does not know. Once at the workplace, s/he meets several other people, having some longer and closer contacts with some of them and some quicker encounters with others. The day after, person A is tested COVID positive, and s/he signals her/his status on the app. The app notifies the different people that person A met about the risky contact that they had. Those who spent more time and had reduced distance with person A receive a high-risk warning, while the others, such as person H and I, receive a lower-risk one.

Figure 2 - Digital Contact Tracing



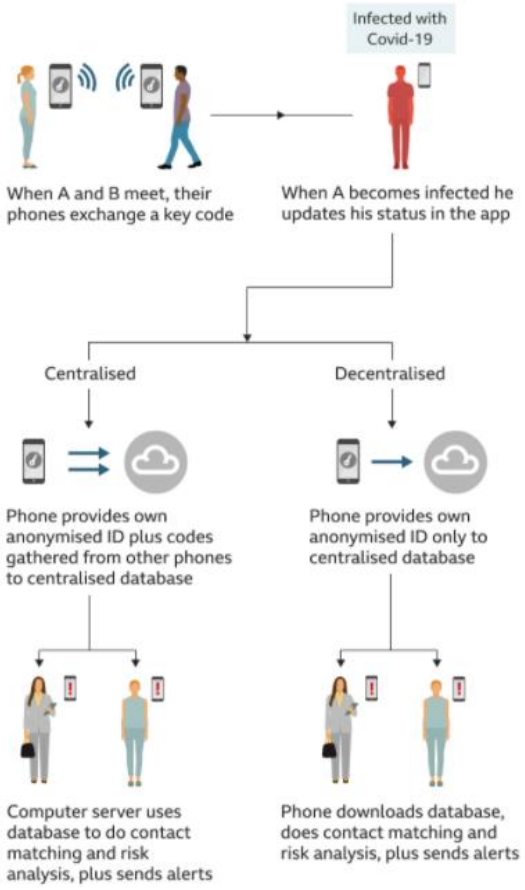
Source: Ferretti et al., 2020

On paper, this digital tracing procedure is quite straightforward, and the benefits with respect to manual contact tracing are quite clear as well. First of all, since the app is signaling possible risky contacts, there is no need for human tracers to get in touch with the many people that person A could have met. Furthermore, person A would not probably recall all the people s/he met at the workplace, while s/he would not for sure know with whom s/he traveled on the train to get there. Provided that all the colleagues and the people on

the train use the same technology, DCT solves these very relevant issues, making tracing not just more efficient, but also more effective (Barrat et al., 2021; Ferretti et al., 2020; O'Neil et al., 2020).

On top of this widely shared general model based on Bluetooth, additional features needed to be designed mainly to manage the information on positive patients. With respect to these issues, two main approaches emerged. *Figure 3* shows how they practically work, while the upcoming pages will consider how they have been developed, by whom, and which role they played in the broad European DCT strategy.

Figure 3 - Centralized approach vs decentralized approach



Source: Criddle & Kelion, 2020

In the decentralized approach, when a person is diagnosed positive, the central database receives a pseudonym from the smartphone app. The central database gathers all the pseudonyms of positive users. Every once in a while, it could be every two hours or on daily basis, depending on the system's policy, each device connected to the central database downloads the list of the pseudonyms of those who tested positive. Then, each device browses locally through this list to check whether some pseudonyms appear also in the contacts that have been registered via the app on the device itself. If risky contacts happened, the system notifies the user.

On the other hand, the centralized approach relies more on the central database. Each device with the

contact tracing app installed uploads on the central database all the recorded contacts, always registered through pseudonyms. When someone gets sick and she or he is tested positive for COVID, the device sends a signal to the central database, which will start browsing the list of contacts that have been uploaded and it will evaluate to which users send a notification, always based on criteria of reach and time of exposure. The main difference is related to where the browsing of risky contacts happens when someone is diagnosed positive:

- decentralized approach: the browsing of the list of positive people happens on each user's device, without the database knowing the risky contacts.
- centralized approach: the browsing happens on and by the central database, which gathers the list of encounters from every user's device.

From a general perspective, the decentralized approach has been considered more privacy-protective, since most of the activities are running within users' devices, to which other players, be it healthcare authorities, companies who developed the app, or the government cannot have access. The centralized approach, on the other hand, could guarantee more useful data for epidemiologists and statisticians' analyses (Criddle & Kelion, 2020; Vaudenay, 2020; Zastrow, 2020).

What has been described so far are models for DCT. How it could be easy to imagine, the design of technologies and implementation of these models into reality did not make tracing positive contacts run as smoothly as pictured in *Figure 2*, mainly because several actors with many different interests, values and strategies were involved.

2. The development of DCT in Europe: design and implementation

The design and implementation of DCT in Europe followed several steps and saw many actors involved in a relatively short amount of time. The worsening pandemic situation since February/March 2020 asked public institutions to rush to find some solutions that could slow down the contagion. However, with respect to digital tracing technologies, one of the many interventions of the early phase of the pandemic, inputs came from scholars and experts involved in several European academic institutions. Public institutions joined this endeavor short after, building on the work that was done by the different groups of academics. Finally, Apple and Google provided their contribution to DCT as well. Such an interplay between different actors may suggest that tracing technology design and implementation took quite some time, but as declared by people from *Inria* (the research center that developed the French app) when interviewed for this research, everything developed at an extremely fast pace.

> *In two and a half months, we did the work that would usually require a minimum of two years (from the call, consortium gathering, etc. till the publication of the app if everything works fine…). During this*

period, the PRIVATICS permanent researchers (we're 7) worked non-stop. The whole project involved approx. 150 persons, working also non-stop for many of them.

Inria

Considering and analyzing how scholars involved in the early definition of protocols, national European public institutions, and Apple and Google, managed the design and implementation phase in this short window of time, is a key step towards answering the research questions that guide this contribution.

2.1 Researchers debate on digital tracing protocols

As already explained in the second chapter, academic interest in digital measurements of social contacts for epidemiological purposes has been around since the 2010s and developed in later years (Cebrian, 2021; Salathé et al., 2010; Smieszek et al., 2016).

Interviewee E has been part of the academic research groups that studied this issue, and explained which role this scientific community played in the early phase of the pandemic:

This community already existed and had already known each other basically for a decade when this crisis began. This community is actually united by another ambition, which is that of digital epidemiology, namely reasoning on epidemiological processes, in particular on the epidemiology of infectious diseases, using non-traditional signals, which epidemiology does not historically use, or that doesn't have the means or techniques to use.

[…] This community had already identified as an important priority, much explored by now, using electronic devices of all kinds to study the mobility and proximity of people, in relation to diseases for which face-to-face proximity, coexistence in an environment, are proxies for transmission. When we found ourselves in January with this shadow of Covid starting to emerge, many of us were already engaged in the initial phase, especially those of us involved in modeling. What happened, especially at the beginning, was when we started thinking, when the paper of... So, the paper by Ferretti and Fraser came out at a certain point, that paper launched the idea to make an app to do contact tracing in real-time.

Interviewee E

The paper by Ferretti and colleagues (2020) has been already mentioned many times in this contribution as well due to its pivotal role in the whole analyzed matter.

Despite being material for the next section, it is inevitable to introduce the national public institutions here, due to the role of the German Robert-Koch Institute in facilitating the development of the Pan-European Privacy-Preserving Proximity Tracing (PEPP-PT).

When Ferretti's paper came out, the Fraunhofer Institute thought of acting as a hub to create a European, ideally interoperable, proximity tracing platform. Why the Fraunhofer? Well, basically for two reasons. The first is that Fraunhofer has an excellent history of setting standards. (…) And then they work (...) closely with the German health protection institute, RKI in Berlin, the Robert Koch

Institute.

(…) So, basically, what happened is that, by the time this project started with RKI as a leader, they already had a network of experts to refer to, and they contacted us to do so, simply because we were people known to the German health protection institute, known and internationally known as experts in contact networks (...). And in this I must say that RKI was not parochial at all, they took the best in the world, let's say, the best in the world which were basically in Europe. This is how we ended up in what became PEPP-PT.

Interviewee E

2.1.1. Pan-European Privacy-Preserving Proximity Tracing (PEPP-PT)

PEPP-PT was announced on April 1st 2020 (Vaudenay, 2020), as a federation of public institutions, companies, and researchers, largely from the cryptography and computer science communities. Its main goal was to develop common technical standards on which building local, interoperable, data secured, proximity tracing technologies (PEPP-PT, 2020b). PEPP-PT soon reached significant numbers of involved actors, with over 130 members in eight European countries, including seven national governments and many that were expected to join (Lomas, 2020b; Ministro per l'innovazione, 2020d).

Initially, PEPP-PT promoted an inclusive approach with respect to the different DCT solutions, namely the centralized and decentralized ones. As expressed in the initiative's FAQs, PEPP-PT is "committed to two principles: First, the privacy of users and data protection must be guaranteed at all times. Secondly, there must be enough flexibility to tailor the technology to the respective requirements of individual countries – while maintaining its interoperability. (…) For this case, there are two approaches – a centralized and a decentralized approach. PEPP-PT is open to both, and will thus offer both models in the future" (PEPP-PT, 2020a). Nevertheless, a sort of preference was expressed towards the centralized approach, considering it "more effective" and "an important element in managing the pandemic, as statistical data on the spread and effectiveness of the measures is thus available more quickly" (*ibidem*).

Once again, *Interviewee E* adds relevant insights on what kind of operations were conducted in PEPP-PT's working groups and how they were managed, which ultimately contributed to jeopardizing the work.

At the beginning of PEPP-PT there was basically... well there was representation from the majority of European countries. There was no well-defined governance structure, in the sense that the engagement was purely technical. We have all been asked to participate in daily conference calls, multiple daily conference calls, on different aspects from the technical to the epidemiological aspects of this challenge. The challenge basically had two components. The first was the design of a protocol, which obviously was as little attackable as possible. Because one thing was certain at the time, the potential damage to data protection was potentially great. The potential benefits, however, of such an app were absolutely uncertain. The only evidence we had was precisely the Ferretti & co paper, although promising, as I said it was made with assumptions that do not exist in real contact networks. Obviously, many of us ran to do simulations on more real data, we became convinced that it had

potential, and therefore we tried to bring - and this was very present in the discussions of PEPP-PT - a balance between the doubt about the potential benefit and certainty on the risk of data protection and privacy.

(…) An issue of PEPP-PT was that no one has ever talked about governance, no one has ever talked about how decisions are made, and no one has ever talked about what the mission was and how conflicts were resolved. This is typically a recipe for problems in a context, which then inevitably became a high-pressure context because by the time a conflict emerged there was no mechanism to resolve it. And the writing was on the wall, it is obvious that by the time this object became invested with a supranational mission to create a European protocol, with representatives joining PEPP-PT from the [national] task forces, others who were in PEPP- PT and because of that they were appointed to the [national] task forces, each of them legitimately conveying the position and wishes of their government, it is obvious that it would have been naive to imagine that we were all aligned. This was not the case. And when there was a major misalignment, there was no mechanism to substantially resolve it. The strong misalignment emerged when there was talk of centralized and decentralized systems.

Interviewee E

Shortly after the half of April 2020, the media started reporting about issues between scholars supporting the centralized system and scholars supporting the decentralized system (the DP-3T group) within PEPP-PT. The most evident element was that research institutions supporting the decentralized approach were removed by PEPP-PT's website (Böck & Schulzki-Haddouti, 2020; Lomas, 2020b), as also recalled by *Interviewee E*.

At this point the split DP-3T/PEPP-PT was created, let's say between the model… the centralized faction and the decentralized one within PEPP-PT. We didn't have a decision mechanism, and basically, in a very very bizarre move, the leadership of PEPP-PT… when I mean leadership, there was no real formalized leadership, but de facto there was a group of people, the founders, Germans, who controlled some things. One of the things they controlled was the website. So, at one point, they expelled DP-3T from the website and that was the step that then ... it was the only thing they could do, there was nothing, no one had ever signed a contract, there was nothing, that was a project that had no legal status, it was a pure scientific collaboration.

(…) At the time it wasn't even called DP-3T, because it was basically one of the PEPP-PT protocols. At that point, when that happened, the Swiss said, "at this point, we give it another name, we make our website with the decentralized protocol" and so that's where it was given the name DP-3T.

(…) The group that then created DP-3T - all of us, Carmela Troncoso at the forefront - agreed that in the spectrum between more data and less privacy, and between fewer data and more privacy, we should have pushed things as hard as possible towards minimizing data and maximizing privacy, because essentially the benefits were uncertain, but the privacy damage, once that door was open, was certain.

(…) What happened there, CISPA left, EPFL left, Fondazione ISI left, and so on, and – basically - PEPP-PT imploded.

Interviewee E

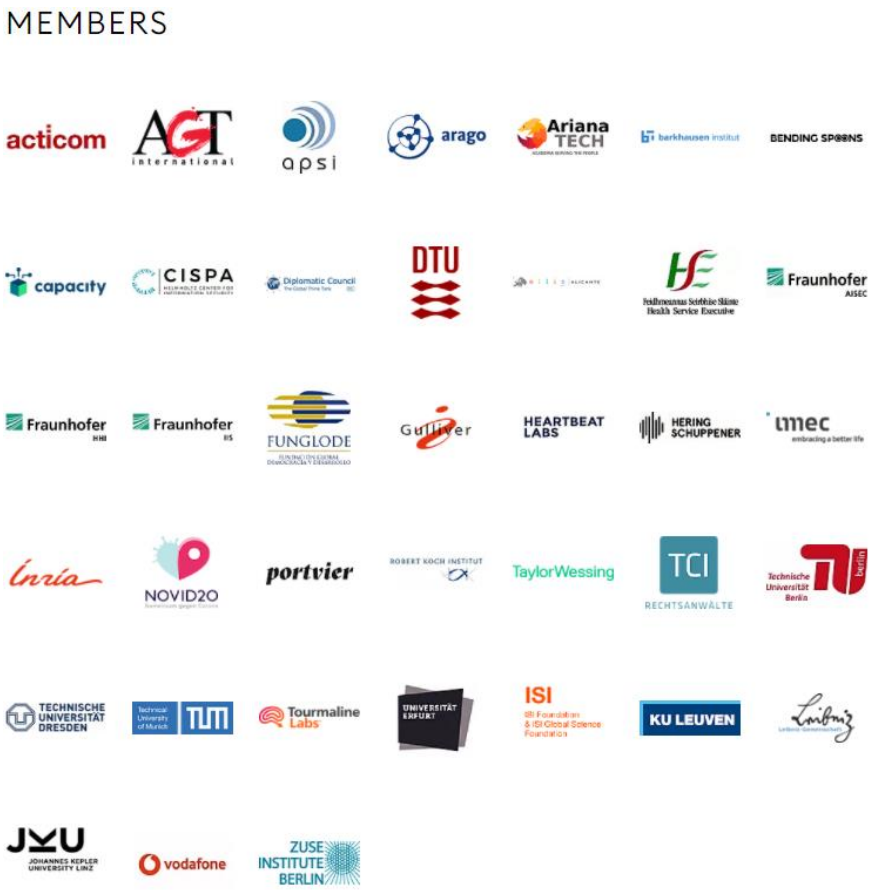
PEPP-PT's "implosion" brought also to a later deleting of the whole website, clearly stating the end of the project.

However, thanks to an online tool called "Internet Archive – Wayback Machine", it is possible to access old versions of several web pages. PEPP-PT's homepage is available on this tool; therefore, it can be proved how, around half of April 2020, some actors have been removed by the members' group. *Figure 4* shows all the members on April 15th, while *Figure 5* shows the members on April 19th, where the logos of some institutions have been deleted. Among those who exit PEPP-PT, the German research institution CISPA explained its resignation from PEPP-PT, mentioning incompatible views, and a lack of "transparency and clear governance" (Klöckner, 2020).

Figure 4 - PEPP-PT members on April 15th, 2020

Source: https://web.archive.org/web/20200301000000/https://www.pepp-pt.org/*

Figure 5 - PEPP-PT members on April 19th, 2020



Source: https://web.archive.org/web/20200301000000/https://www.pepp-pt.org/*

2.1.2 Decentralized Privacy-Preserving Proximity Tracing (DP-3T)

DP-3T emerged from PEPP-PT as a "system for secure and privacy-preserving proximity tracing at large scale. This system provides a technological foundation to help slow the spread of SARS-CoV-2 by simplifying and accelerating the process of notifying people who might have been exposed to the virus so that they can take appropriate measures to break its transmission chain. The system aims to minimize privacy and security risks for individuals and communities and guarantee the highest level of data protection" (Troncoso et al., 2020, p. 3).

Several scholars appear as authors of the whitepaper that presented the main characteristics of this system. The logos of their institutions were reported as well, as pictured in *Figure 6*, and it is interesting to notice how three of them (EPFL, ETH, and CISPA) were initially included on the PEPP-PT website (*Figure 4*).

Figure 6 – DP-3T leading institutions

Source: Troncoso et al., 2020

Besides more technical elements of the decentralized proposed solution to proximity tracing, Troncoso and colleagues (2020) clearly defined the boundaries of their initiative. They stated that DP-3T is not interested in tracking positive COVID-19 cases, which means that the system does not aim at detecting whether positive people comply with medical orders. Furthermore, the system does not identify clusters of contagion based on GPS data. Moreover, DP-3T was not developed to gather data for research purposes. *Interview E* clearly explained the rationale that guided the development of this system:

> *So, our position was that we need to create a protocol that minimizes by design, by default, the collected data, and focuses on the single thing we want to do. Which is that, if I know that you are confirmed positive today, I want to notify as quickly as possible all the people who have been in contact with you and who have used the app during the last 3/4/5/6 days. So, the DP-3T protocol was born just as a response to "how do we design a technical protocol that does this and only this?", Without materializing a social graph, with a backend server that knows nothing. The truth is, if one hasn't been exposed, or if one isn't positive, the server doesn't even have to know you exist.*
>
> Interviewee E

How the situation developed for the centralized and decentralized systems is briefly pictured by *Interviewee U*, who participated in DP-3T. The international support for DP-3T grew, while the approval for the centralized quickly decreased, also due to a joint statement signed by more than 300 scholars against this kind of solution (*Joint Statement on Contact Tracing: Date 19th April 2020*, 2020)

> *We ended up in the situation where there were a lot of international researchers going to DP-3T and contributing quite a bit and there was a lot of development then. There were apps that were coming out very quickly out of Switzerland on their GitHub repository, and also politically the support for centralized solution seemed to disappear, for whichever reason.*
>
> Interviewee U

2.1.3 ROBust and privacy-presERving proximity Tracing (ROBERT)

> *What was left of PEPP-PT was the French and German sides, and then all the others. France and Germany continued with a centralized approach and created what was called ROBERT, and basically it was a disaster. In the sense that it didn't work for a variety of reasons, but mainly because it went against the ecosystem they wanted to use the apps on, and this is why Apple wouldn't allow them to run in the background.*
>
> Interviewee E

> *The research community of cryptography, security, and privacy, which was also historically quite close to these issues of respect for privacy, moved against this type of approach mainly because it had been seen that there was a possible alternative, therefore that the same goal could be achieved with another solution that was not so invasive.*
>
> Interviewee F

ROBERT is the centralized protocol proposed by the French research Institution Inria and the German Fraunhofer AISEC. On April 18th, 2020, the two institutions published a whitepaper that stated the aims and principles of the centralized protocol. "To protect user's privacy, proximity tracing applications should follow the data anonymized principle of GDPR, and only collect the information required to achieve the main purpose of these applications: notifying users that they have been in close proximity of COVID-19 virus carriers. In particular, proximity tracing applications should not collect any geolocation data; instead, they should rely on the collection of temporary pseudonyms. Proximity tracing applications should provide the highest privacy standard for their users, and protect them from the central authority, from other users and from other malicious third parties. Most importantly, such applications should not be turned by users into a spying system especially to learn whether people living or working in a specific location are diagnosed with COVID-19 or not" (Inria & Fraunhofer, 2020, p. 2).

These general aims and principles do not seem to differ from the initial ones proposed by PEPP-PT and DP-3T. However, the excerpts reported in the opening of the paragraph show how the decentralized solution's proponents did not express supportive statements toward the centralized approach. Moreover, the empirical material from Inria confirms the very different perspectives between the two protocols, curiously on the same matter of privacy and data protection:

> *[At] beginning of April, after several discussions with EPFL, PRIVATICS [ed. The research group at Inria] decides to adopt a centralized approach and gets closer to Fraunhofer (they have an almost operational solution). [The] main reason for that decision: being decentralized raises major privacy issues when considering the need to disseminate the COVID+ status of persons who declare themselves through the app, incompatible with GDPR.*
>
> *(…) [The] first natural reaction when facing the problem is to think about a decentralized scheme. This is what we explored first. However, in the very first days of April, it became clear that the major*

> *downside is the need to share all the pseudonyms of all COVID+ persons in order to let each smartphone assess risks (are those pseudonyms part of those I've crossed during the past few days?). In other words, it means sharing a database of health data (COVID+ status) that is only pseudonymized (pseudonyms are shared through the daily TEK keys that enable to compute them). This is in total contradiction with the basic GDPR rules regarding sensitive data protection.*
>
> Inria

Furthermore, the French institution also criticizes how those involved in the decentralized approach managed public relations, media exposure, and influence on public institutions.

> *Google / Apple/ EPFL and others could have promoted their solution in a fair manner, comparing the respective merits of approaches. But they decided to discredit all the other solutions, through scientific, political, and technological lobbying. That's something totally different. Of course, doing so, they never explained that GAEN comes with a major issue: it does not protect the health status of those who declare themselves through the app. This issue has never been mentioned at that time.*
>
> Inria

What started as a technical task towards the definition of technological protocols that could digitally support the contact tracing process, soon – in less than a month – became a highly political and discussed matter. Many of the contributions analyzed in the first chapter should have already suggested that purely technical issues do not exist, since social dimensions are always involved. The social and political dimensions in DCT quickly became of pivotal importance. As stated by *Interviewee T*, different actors brought their political interests in the digital technology design and implementation process. Furthermore, privacy and data protection became the disputed guiding principles and aim to reach, offering an apparently common ground in this set goal, but defining very diverse sociotechnical pathways to get there.

> *It became clear that there was a large political angle to all of this. It is essentially about... somehow about, well, establishing the standard for contact tracing in Europe within the foreseeable future.*
>
> Interviewee U

As already anticipated by one of the previously mentioned interviews excerpts, the complexity around the definition process of DCT grew when public institutions entered the field.

2.2 National public institutions and the EU get involved

National public institutions in each country played a key role since the early phase of DCT design and implementation, assigning the different tasks to the Healthcare Ministries, sometimes to the Innovation ones, or national research institutions, depending on each context.

With respect to the analyzed cases in this research, the Italian Government publicly started dealing with digital tracing solutions towards the end of March 2020. On March 23rd, the Innovation Ministry, alongside the Health one, the national department of health (Istituto Superiore di Sanità), the WHO, and an

interdisciplinary scientific committee launched a three-days call for contributions to national research institutions and the private sector. The goal was to identify "the best digital solutions available in relation to telemedicine and home care apps, and technologies and strategies based on technologies for "active" monitoring of the risk of contagion, and to coordinate the adoption and use of these solutions and technologies at a national level, in order to improve the results in terms of monitoring and contrasting the spread of Covid-19". The Italian Innovation Ministry stressed how a "timely employment of emerging technologies (data analytics, AI) (…) in other countries has been proved as a very effective weapon for monitoring and containing the coronavirus SARS-CoV-2 contagion" (*ibidem*).

The Innovation Ministry, which can be considered the leader of the aforementioned group of public institutions, established a task force of experts, divided in many groups, to evaluate the proposals that answered the call (Ministro per l'innovazione, 2020e). The same Ministry guided, from the public institutions' side, the whole process of DCT implementation in Italy, as will be later presented in the dedicated chapter.

In Germany, a pivotal role has been played by the Robert Koch Institute (RKI). The RKI is "the government's central scientific institution in the field of biomedicine. It is one of the most important bodies for the safeguarding of public health in Germany" (RKI, 2019) which deals with many health-related tasks, such as identification, surveillance and prevention of disease, and informing and advising political decision-makers (*ibidem*).

As the interviewee from RKI recalls, discussions on DCT started in March 2020 also in Germany.

> *It started quite early in March last year [*ed. 2020*]. We had some discussion with different people, in Germany there is this kind of digital... it's called digital dialogue [ed. Health Innovation Hub (HIH)]. It belongs to the Government, and there are people from civil society, industry partners, and also scientists and politics. They came up with the idea how to tackle the covid pandemic. (…) There was this very self-intrinsic group back in the days, led by a member of the Fraunhofer, it's a big organization in Germany, who came with the idea of digital contact tracing. The Robert Koch Institute was involved from the beginning on, even the Ministry of Health was also quite early involved. In the beginning there were mainly discussions how it can be done, which technology should be used and the specialist from Fraunhofer Institute were doing a tremendous job in how Bluetooth can be used for identifying possible infection chains. So, the discussion started back in the days, and I think the first weeks and months there were strong discussions about which technology to use.*
>
> Interviewee RKI

As the specific chapter on Germany will show, German national public institutions did not only play a pivotal role in the initial phase, especially with their health-related authorities but also after some weeks when discussions on DCT developed. Germany initially followed a centralized approach, but then decided to switch to a decentralized approach with a Government decision (Lomas, 2020a).

With respect to France, the national public institutions' leadership of DCT was held by the Minister of State for Digital and telecommunications, Cedric O, and the Minister for Solidarity and Health, Olivier Véran. Since April 7th, 2020, the two ministries started collaborating with Inria on the development of a tracing solution for France (Inria, 2020b). The role of France's Government was key throughout the whole process, most importantly because, as it will be later shown, they decided to rebrand and reboot their official app under a new name (Reynaud, 2020).

It is interesting to notice how all the three analyzed cases were initially involved in the PEPP-PT framework. In the previously reported *Figure 3*, the logos of Inria and the RKI show the involvement of France and Germany in the project. Italy is represented as well through the logo of Bending Spoon, which was the company whose solution was selected after the Innovation Ministry's call for contributions.

As *Interviewee D*, member of one of the groups that evaluated the Italian tracing solutions, declared: in the early days of DCT design and implementation in the different European countries, a common EU framework was still unavailable.

The EU Commission started publishing guidelines and principles for digital technologies in the fight against COVID in the early days of April 2020 (European Commission, 2020d), emerging from the work done by the eHealth Network since the end of March (European Commission, 2020c). The Commission adopted, on April 8th, "a Recommendation towards a common Union toolbox for the use of technology and data to combat and exit from the COVID-19 crisis, in particular concerning mobile applications and the use of anonymized mobility data. (…) The purpose of the Recommendation is, inter alia, to develop a common European approach ("Toolbox") for the use of mobile applications, coordinated at EU level, for empowering citizens to take effective social distancing measures, and for warning, preventing and contact tracing to help limit the propagation of the COVID-19 disease. The Recommendation sets out the general principles which should guide the development of such a toolbox and it indicates that the Commission will publish further guidance, including on the personal data protection and privacy implications of the use of applications in this field" (European Commission, 2020b, p. 1). With these documents, the EU Commission defined some guiding principles. It identified national health authorities as controllers responsible for the compliances of digital technologies with the GDPR. The Commission expressed the need for ensuring that individuals remain in control of the newly developed technologies, that should be centered around data protection and privacy, minimizing the gathered information. Moreover, the Commission identified a key role for national Data Protection Authorities, which should express evaluations on their respective Governments' apps (European Commission, 2020b, 2020d).

The EU Commission guidelines introduced to the analysis some additional relevant public institutions actors, such as national healthcare authorities and Data Protection Authorities. The role that each one of them played in the implementation of DCT in each analyzed context will be mentioned in the upcoming chapters.

After having analyzed the role of the different research groups behind the tracing protocols, and having introduced the initial involvement of National Governments, postponing to the later chapters more deep considerations, it is time to focus on the third group of relevant actors that contributed shaping DCT in Europe.

2.3 The Exposure Notification Framework: a decentralized solution by Apple & Google

On April 10th, 2020, Apple and Google released a joint statement:

> "Google and Apple are announcing a joint effort to enable the use of Bluetooth technology to help governments and health agencies reduce the spread of the virus, with user privacy and security central to the design.
>
> Since COVID-19 can be transmitted through close proximity to affected individuals, public health organizations have identified contact tracing as a valuable tool to help contain its spread. A number of leading public health authorities, universities, and NGOs around the world have been doing important work to develop opt-in contact tracing technology. To further this cause, Apple and Google will be launching a comprehensive solution that includes application programming interfaces (APIs) and operating system-level technology to assist in enabling contact tracing. Given the urgent need, the plan is to implement this solution in two steps while maintaining strong protections around user privacy.
>
> (…) All of us at Apple and Google believe there has never been a more important moment to work together to solve one of the world's most pressing problems. Through close cooperation and collaboration with developers, governments and public health providers, we hope to harness the power of technology to help countries around the world slow the spread of COVID-19 and accelerate the return of everyday life" (Google, 2020a).

The first step of the partnership was reached in May when the two tech corporations released their Exposure Notification Framework (ENF). The two firms "worked together, reaching out to public health officials, scientists, privacy groups and government leaders all over the world to get their input and guidance" (Google, 2020b). They proposed a solution, basically a tracing protocol like DP-3T or ROBERT, which solved the Bluetooth's communication issues between Android (Google) and iOS (Apple) devices. Thanks to the ENF, public health agencies could develop their own systems, as clearly indicated by the two firms:

> "Our Exposure Notifications technology is available to public health agencies on both iOS and Android. What we've built is not an app—rather public health agencies will incorporate the API into their own apps that people install. Our technology is designed to make these apps work better. Each user gets to decide whether or not to opt-in to Exposure Notifications; the system does not collect or use location from the device; and if a person is diagnosed with

> COVID-19, it is up to them whether or not to report that in the public health app. User adoption is key to success and we believe that these strong privacy protections are also the best way to encourage use of these apps.
>
> (…) Today, this technology is in the hands of public health agencies across the world who will take the lead and we will continue to support their efforts" (Google, 2020b).

The second phase of the Apple and Google's joint effort on DCT came in September 2020. The two tech firms further developed their framework, adding a very important feature. With the updated ENF version, Governments or health authorities could avoid developing full tracing apps. The authorities could simply set the features they prefer, such as risk scores, recommendations to users, and external links, then Apple and Google managed to implement tracing functionalities on their operating systems (Brandom, 2020).

From a technical design point of view, the solution developed by the two US tech firms follow the decentralized approach that was presented at the beginning of the chapter:

> "Once enabled, users' devices will regularly send out a beacon [i.e., signal] via Bluetooth that includes a random Bluetooth identifier — basically, a string of random numbers that aren't tied to a user's identity and change every 10-20 minutes for additional protection. Other phones will be listening for these beacons and broadcasting theirs as well. When each phone receives another beacon, it will record and securely store that beacon on the device.
>
> At least once per day, the system will download a list of the keys for the beacons that have been verified as belonging to people confirmed as positive for COVID-19. Each device will check the list of beacons it has recorded against the list downloaded from the server. If there is a match between the beacons stored on the device and the positive diagnosis list, the user may be notified and advised on steps to take next.
>
> To power this solution, both companies have released software that enable Exposure Notifications from public health authorities that work across Android and iOS devices, while maintaining user privacy" (Apple & Google, 2020).

Since this technology design follows the decentralized approach, the DP-3T protocol shares many elements with what has been developed by Apple and Google (Troncoso et al., 2020).
Besides the technological features, the two tech firms set clear principles connected to their system. As the excerpts reported so far may have suggested, privacy and security are among the most important elements. Apple and Google expressed many times how they intended to work closely with national authorities and are very strict on data protection:

> "Access to the technology will be granted only to public health authorities. If they create an app, it must meet specific criteria around privacy, security, and data control." (Apple & Google, 2020)
>
> "Our technology is designed to make these apps work better. Each user gets to decide whether or not to opt-in to Exposure Notifications; the system does not collect or use location from the device; and if a person is diagnosed with COVID-19, it is up to them whether or not to report that in the public health app. User adoption is key to success and we believe that these strong privacy protections are also the best way to encourage use of these apps." (Google, 2020b)
>
> "Apps will receive approval based on a specific set of criteria designed to ensure they are only administered in conjunction with public health authorities, meet our privacy requirements, and protect user data." (Apple & Google, 2020)

The announcement of the joint effort by the two tech firms and the characteristics of their framework received a large share of attention in the media at that time. Next to those contributions reporting the news and the main features of the proposed solution, more critical voices were raised (Barber, 2020; Doffman, 2020). Some media said that "Apple is effectively dictating to governments the privacy levels that their contact-tracing apps must meet" (Paul, 2020), or that "Google and Apple outflanked governments in the race to build coronavirus apps" (Scott et al., 2020), or that "countries keep bowing to Apple and Google's contact tracing app requirements" (Newton, 2020).

Such strong positions emerged because of the Bluetooth issues with DCT that are going to be covered in the next section. For now, it should be enough to know that Apple does not allow apps to access Bluetooth when the users is not directly interacting with them, mainly for privacy and data protection reasons. This would mean that contact tracing apps would not be able to register encounters through Bluetooth when a person has the phone in the pocket (Hern, 2020).

Apple and Google's framework solved these problems but established some clear privacy and data protection principles that needed to be followed by those who wanted to rely on the ENF.

To better understand whether Apple and Google's role was that critical in defining the design and implementation of DCT to the point that they made "countries bow" (Newton, 2020), it could be useful to consider the position of those who have been involved in the process.

With respect to the Italian case *Interviewees A*, *B*, *E*, *F*, and *G* considered Apple and Google's involvement as a significant gamechanger, also defining it as a "tsunami" that made perspectives on DCT change. This largely shared position is clearly expressed by *Interviewees E* and *A*:

"The announcement from Apple and Google arrived. We knew about Apple [involvement with scholars developing DCT protocols, especially DP-3T], we didn't know that Apple in the backchannel was talking to Google. So, when we saw the joint announcement, we were all very surprised, we didn't expect it. At that point, that one dictated law, they made it clear that this would initially be a sort of library mechanism, with constraints on the apps that could use it. Then it would be migrated within the operating system, with even tighter constraints.
Basically, they made a policy - long story short - they decided what was the approach that, within their respective ecosystems, should be used. We can reason… A lot has been written about whether this was right or wrong, but the truth is that this [ed. the smartphones infrastructure] is a private ecosystem, and this [ed. control on apps and Bluetooth features] is a control lever that they had, and they decided to use it."

Interviewee E

"In my opinion, what really changed the discussion [on Immuni's design and implementation] was Apple and Google's announcement. At that point, the critical part of the protocol was managed by Apple and Google, the apps were just a sort of infrastructures running on what Apple and Google were doing."

Interviewee A

Interviewee G, who was part of the team that initially developed the Immuni proposals, explained what role the two tech companies played from the technological point of view:

"The programming of Immuni at the beginning was done by Bending Spoons also at a low level, that is also in the management of Bluetooth, because at that time there were no software stacks that would allow you to do what was needed. So they went out of their way to try and do it. Keep in mind that the problem was far from trivial, because you have different phones, so with different Bluetooth powers, you have a whole plethora of messes for which you had to somehow build a library that would allow you, once you locate the type of phone which is on the other side, to measure the average distance. [...] Then, at some point, Apple and Google came out saying that that stack, that is, the management of Bluetooth, they would do it. [...] Now what problems has this stuff created? It tended to create an adoption problem, because they basically decided to put it from a certain operating system onwards. Which meant that, for example, IPhone6s couldn't have it [ed. the contact tracing app]. Let's say this has created problems in communication, in adoption: that is, there is a certain percentage of people who could not have it, unless they changed the phone. And then it created problems, let's say controversies in the public debate, because as usual it started saying that Apple and Google would take our data, they would use it to do dramatic and bad things and so on. Very ridiculous positions because they don't realize that Apple and Google have very different data and not those that would have been generated by Immuni, which are pseudo-random codes, absolutely useless, while Apple and Google have our credit cards, know our movements and so on."

Interviewee G

With respect to Germany, SAP stated, yet with fewer details and personal perspectives, the fact that Apple and Google's framework defined clear and rigid guidelines for building the DCT app:

> *So, the centralized and decentralized thing was decided up front, so that was a given. Also it was pretty much clear since Apple and Google decided on the centralized and decentralized approach by introducing their framework, that was basically there.*
>
> Interview T_1

As already mentioned, the ENF was not employed in France. One of the interviewed cryptographers who studied the French app, expressing his own opinion on the matter, offers interesting insights on how Google and Apple's involvement was perceived:

> *"We don't really trust Apple and Google to be nice with this data, and especially healthcare data, and we don't want to send them to the US or to company that are linked to the US at least. That was really scary to see them enter the field and say "we are going to provide you with the solution, but we keep control of the core of it". So, it was really a mix of very good things and very bad things. So, I've discussed with people that worked on the GAEN [i.e.: Apple and Google's framework] directly, and they were nice people that were trained to do nice things, it was good crypto in the protocol, but you never know what happens behind and you never know if someone in the management, or whatever, is going to get some pressure to change something to change their mechanism and make them able to enter data. That was really scary."*
>
> Interviewee R

With respect to the national institutional positions towards the two Big Techs, which will be better developed in the following chapters, Italy, for instance, considered them just as technology providers with no involvement in data management (Garante per la protezione dei dati personali, 2020). On the other end, France considered their involvement unacceptable since citizens' health information and sensible data were involved (O, 2020).

Apple and Google's control over almost all commercialized smartphones, as will be better described in the next section, makes them very important actors in the process of design and implementation of a technology that is supposed to run on these kinds of devices. Furthermore, the framework developed by the two tech firms contributed to solving Bluetooth's communication issues, and at the same time set rigid and defined rules for the development and implementation of tracing solutions. Therefore, the two Tech Firms should be considered, together with the two previously analyzed actors, among those who most significantly contributed to shaping DCT. The next steps in this contribution are indeed oriented toward understanding whether the perspectives, values, and strategies of one of these actors prevailed over others, but first some additional elements should be considered.

2.4 An invisible yet pivotal non-human actor: Bluetooth

Several of the contributions analyzed in the first chapter reflected on the issue of technology's materiality and the boundaries set by its affordances (Akrich & Latour, 1992; Latour, 1992a; Russell & Williams, 2002). Without any surprise, even digital technology deals with materiality and affordances, deriving from how they have been designed (Bucher & Helmond, 2018; Pink et al., 2016). Furthermore, actor-network theory showed how agency is not only a feature of humans, but also non-human (Latour, 1996). Humans and non-humans actants have competences and perform acts that have mutual influences within the setting where they are situated (Akrich & Latour, 1992). Scholars have been showing how often humans and non-humans need to come to terms when developing new technology (Law & Callon, 1992). It often happens that human actors delegate to non-humans' agency specific tasks (Sismondo, 2010).

With respect to the DCT's design and implementation process, the smartphones' Bluetooth played a key role. Therefore, building on the theoretical background briefly reported here, and more largely covered in the first chapter, some considerations on Bluetooth, a non-human actant, find room in this chapter, after having covered other influential actors that contributed shaping DCT development.

Bluetooth is a technology developed and integrated on almost every smartphone as a communication protocol, employed nowadays mostly for connecting the smartphone with other devices, such as wireless earphones, speakers, or cars. With respect to DCT, the communication feature of the Bluetooth technology has been repurposed also for measurement aims, namely registering the time of exposure and distance among devices (Jacob & Lawarée, 2021). This new use of Bluetooth, which exiles its original communication purposes, likely brought inaccuracy of measurements within specific contexts, such as the already mentioned example of public transportation (Leith & Farrell, 2020a). Furthermore, as *interviewee E* who participated in the development of DCT protocols stressed, Bluetooth works differently across different devices:

> *We basically focused on the protocol, and then on a problem that nobody talks about which is one of the big problems of using Bluetooth to do proximity detection, that Bluetooth was not really born for that. Above all, the electronic circuits or the radio Bluetooth implemented in different smartphones have different antennas, antennas are placed differently, electronic circuits are different. So, with the same parameters that the operating system sets for the radio, the radio behavior, what comes out on the radio channel is very very different in terms of power, and therefore it was not absolutely obvious that this could work with precision through the ecosystem, which is diverse and very heterogeneous among European citizens.*
>
> Interviewee E

Nevertheless, Bluetooth, despite not being designed for measuring, is significantly more precise than a measuring technology that runs on most smartphones as well: the GPS. It has been shown how GPS does not provide precise measurements within a certain distance and it does not work properly in-door, making it

completely useless for DCT purposes (Bay et al., 2020).

As has been shown by an empirical study conducted in Singapore, the issue of sensitive measurements could be solved by wearable locating systems which significantly outperformed Bluetooth tracing systems (Huang et al., 2020). It is quite easy to imagine how big of a task would be to provide new wearable systems to the whole population of a country. Bluetooth, on the other hand, is available on almost every smartphone, a type of device that is already widespread in the population (PEPP-PT, 2020b), at least in Europe where the smartphone penetration rate is 76% (Statista, 2022b).

Besides its role in measuring time of exposure and distance, Bluetooth is pivotal also due to the way it is managed on smartphones, whose ensemble could be somehow considered as an infrastructure on which DCT runs. The companies that control more than 99% of the mobile operating systems, namely Apple and Google (Statista, 2022a), have Bluetooth policies that largely impacted the implementation of tracing apps. In the early days of DCT, it quickly emerged that Apple's policy toward Bluetooth use was a big problem that prevented tracing apps to work properly (Hern, 2020; Ministro per l'innovazione, 2020d). In general, Apple denies any app operating on their devices to access Bluetooth while in the background, meaning while the app is not visible to the user on the screen, in order to reduce possible privacy violations (Hern, 2020). *Interviewee F*, who contributed to the development of DCT protocols, covered this issue as well.

> *There is a very simple thing that seems trivial but then in the end it is not, these applications [DCT ones] must work in the background, when our phone is, not off, but the screen does not work, so for instance we have the phone in our pocket. It is important that they do it for these kinds of [DCT] purposes. Now, for security reasons, already in the past, for how mobile operating systems work any application does not have permission to be able to use Bluetooth when it is not working. In fact, one of the reasons was also to avoid possible tracking.*
>
> Interviewee F

This issue has been solved, as already described, by a joint tracing protocol released by Apple and Google (Google, 2020a), whose influence on the smartphones' infrastructure is of utmost importance.

> *The global [smartphone] market is fundamentally conditioned by two private companies since the operating systems that work are from two private companies. These operating systems, as they were conceived, even for valid reasons, decide which applications can work since they need permissions. This is (...) dictated by them. Let's say that this thing in the field of computers didn't happen because (...) everyone can install on a machine an operating system that is not from Microsoft or Apple. On them we have this freedom but in the world of smartphones… Yes, maybe it is possible that you can make a smartphone on which you install another operating system, but in practice, it doesn't work this way because, if you want to use the applications that the whole world uses, you must undergo these companies.*
>
> Interviewee F

DCT models relying on smartphones and Bluetooth technology needed to come to terms with the fact that Bluetooth was not designed for measuring purposes and private companies control some of its features. Nevertheless, no other reasonable option was available since the main other smartphone technology, namely the GPS, works even worse, and it is not reasonable to provide the whole population with more efficient tracking devices. Therefore, it is quite clear how the models pictured in *Figure 2* and *Figure 3* clash with the affordances of technologies in use, which add to the issues emerging with the human actors involved.

3. The use of DCT in Europe

The design and implementation phases had different durations across the European countries that decided to develop a DCT strategy. As *Table 1* in the previous chapter showed, Latvia was the first country that launched a tracing app at the end of May 2020, while Cyprus was the last one in the same year, rolling out its solution at the beginning of December. Therefore, the use phase started with differences over many months among the European countries. However, Italy, France, and Germany launched their app at the beginning of June and July 2020, being among the first who developed a DCT strategy in Europe. What is relevant to consider here with respect to the use phase concerns the type of actors that, from a general point of view, were involved. Going back to *Figure 1* at the beginning of the chapter, it would be easy to notice how two of the most relevant actors that have been considered so far did not participate in this phase. First of all, the experts who contributed to developing the protocols, being them PEPP-PT or DP-3T, did not have a significant role once the apps were made available on digital stores. As extensively described above, the role of those who developed DP-3T and the other protocols was mainly related to defining a socio-technical framework on which then build different applications. Therefore, once the applications have been built and launched, the primacy of this group faded. France is a peculiar case because those who developed the ROBERT protocol were also involved in operating and managing the app, so the development team at Inria kept being strongly involved in the StopCovid and TousAntiCovid projects.

With respect to Apple and Google, once the two companies developed their framework, they put it in “the hands of public health agencies across the world who will take the lead” (Google, 2020b). The two tech firms as well were not strongly involved in managing the use of DCT apps developed on top of their structure. As presented in the dedicated section, their contribution did not stop with the launch of the Exposure Notification Framework in May 2020, since they updated it in September 2020, but other actors were the most relevant ones during this phase.

The users of the app are among the actors that played the most relevant role once the apps became available in digital stores. The STS literature tells that, when developing technology, designers try to envisage, and therefore shape, the role that the users will play, and the activities that they will perform with the artifact. However, it can happen that the users decide to employ the technology in a different way than the one envisaged by the designers (Akrich, 1992). These different uses of a technology, not envisioned by designers

but carried out by users, could also reshape the technology itself (Mackay and Gillespie, 1992). That is why an arrow connects the use phase with the design phase in *Figure 1* at the beginning of the chapter. The chapter on the German case will clearly show how users' voices can change some of the features of the technology. However, there is a more straightforward example that can be considered here, postponing a more precise analysis of the role of users in DCT to the chapters on the case studies.

As already mentioned several times, the download of DCT apps was not mandatory for citizens in Europe. With the decision on whether to participate or not in DCT left to the individual, the impact that each person can have on this kind of solution is of utmost importance. A citizen, just by deciding not to become a user of the technological artifact, could interrupt the implementation of the digital tracing policy, at least for his or her individual position.

Some additional actors became relevant once the app launched, such as local health care authorities. Analyzing these actors and their role with respect to each national context seems the best approach to offer more detailed contributions, therefore the analysis is postponed to the upcoming chapters.

To conclude this first step of the analysis of DCT during the COVID-19 pandemic, an overview of how it was managed across the World is quite important.

4. DCT strategies across the World

There are many countries that have been under the spotlight during the COVID-19 pandemic for the most diverse reasons, China is among these because it is where the first cases were spotted. Therefore, it is interesting to consider whether and how DCT was implemented there.

DCT apps were first introduced in Wuhan through two technological solutions developed on the platforms of WeChat and Alipay. On both the systems, users were required to upload their phone number, home address, and other personal information. Moreover, both the systems requested some health parameters, such as body temperature and symptoms, and recent travel history (Boeing & Wang, 2021). Furthermore, the phones would measure proximity with other mobile devices and rely on GPS. All the information is then uploaded to a central database where artificial intelligence systems evaluate the risk profile of each user, assigning him or her a risk code which determines the possibility to move freely, within a restricted area, or the need for a quarantine (Bonsall et al., 2020). By May 2020, this system was extended to 300 Chinese cities, without being compulsory, but required to move around and access some basic activities or services, such as public transport (Bonsall et al., 2020; Kim et al., 2021).

The technological solution developed by China, to the eyes of *Interviewee D*, one of the experts involved in the evaluation of the Italian DCT alternatives, appeared unacceptable for the Italian context, while other solutions, such as South Korea's one, had more interesting elements to evaluate.

South Korea's digital tracing strategy against COVID could count on the expertise and legal tools developed during the 2015 MERS outbreak. During that period, "the government amended their Infectious Disease

Control and Prevention Act (IDCPA) to provide authorities with greater ability to collect and analyse data from infected individuals during outbreaks, whereby, private companies had to provide data to the Korea Centre for Disease Control and Prevention (KCDC) about their customers" (Ryan, 2020, p. 384). With the COVID outbreak, the Korean authorities relied on this set of norms to strengthen manual contact tracing, using location data and credit card transactions to identify the movements of infected people and try to reduce the impact of the contagion. The data from 22 credit card companies, 3 telecommunication firms, the National Police Agency, and the Credit Finance Association of Korea contributed to generating the most complete picture of a positive person's recent activities. Thereafter, people who spent time in the same area of an infected person get notified via mobile text message. Furthermore, the national authorities, after having anonymized data of positive people, upload them online so that people could autonomously check whether they frequented risky locations. Once the number of infected people raised, it became impossible for people to effectively browse this database. Therefore, apps that could automatically check this database were developed, showing dangerous hotspots on maps (Park, 2021; Ryan, 2020). Another Korean app, more strictly related to quarantine and positive case management, connected users to civil servants in public health clinics. The users were required to input their symptoms on the app twice a day, so the professionals could monitor them. Furthermore, the app registered the location of the phone, sending a notification to both the user and the public servant whether the quarantine was violated (Kim et al., 2021).

However, the most similar solution to what was developed in Europe is the DCT app that the Government Technology Agency and the Ministry of Health implemented in Singapore (Bay et al., 2020). The TraceTogether app relies on the BlueTrace protocol (Bay et al., 2020; Huang et al., 2020), basically a decentralized protocol as it has been described by European scholars and experts (Vaudenay, 2020). TraceTogether was the first Bluetooth-based DCT solution in the World, and it experienced the same problems that the first European solutions experienced with Bluetooth on Apple's devices. Singapore's developers partially solved this issue by trying to convince users to keep their tracing app open in the background, especially in more crowded environments. Furthermore, they implemented other features such as power-saving modes to keep the app running in the background without using too much energy, and push notifications to remind users to keep the app open (Bay et al., 2020). Due to its characteristics, the Singapore solution was among the main points of reference to the first version of Immuni which was presented to the Ministry of Innovation call for contribution (Ministro per l'innovazione, 2020d).

From a general point of view, *Interviewee B,* who was involved in the evaluation of Immuni and the other candidates in becoming the official Italian DCT app, explained how the Eastern solutions to DCT have been analyzed by the group of experts of the national task force. However, the goal was not to find technological solutions to import, but to consider which could be the benefits of these kinds of solutions. Some of the features of the eastern DCT apps, such as data protection and download policies, were too invasive for the

Italian and European standards, but – the interviewee suggests – could have played a role in the greater success of these apps in those countries.

If Eastern countries, such as Singapore, South Korea, and China, were among the pioneers and early adopters of DCT technologies, the United States needs to be considered a latecomer. In some federal states, they even never actually implemented a digital tracing solution. Indeed, the approach to this issue in the U.S. was left to each state's Governor. Therefore, initially, very different apps, also from a technological point of view, were developed. A 1st June 2020 Senate bill on privacy requirements of contact tracing apps defined a more common framework in which the States could operate (Park, 2021). Thanks to Apple & Google Exposure Notification Framework, especially with the September 2020 release, from a technical point of view the apps ultimately converged towards a common model (Ladyzhets, 2021). However, as of June 2021, still less than half of the U.S. States and territories had implemented a digital tracing solution (GAO, 2021). Among people, attitudes towards DCT were quite fragmented as well, with some studies showing that most Americans were willing to download these apps and others showing the exact opposite (B. Zhang et al., 2020).

These are just some of the many countries in which DCT strategies have been fully or partially implemented. The MIT, until June 2021, registered 49 technological solutions with tracing purposes across the Globe (O'Neil et al., 2020). Among these, as the research aims clearly stated, this study focuses on Italy, France, and Germany; it is finally time to consider each one of them in the following three chapters.

Chapter 5 – Immuni and digital contact tracing in Italy

It should be now clear how DCT development is a complex socio-technical matter, with many involved actors that interacted one another in a very reduced time-window. At this point, the goal should be to try to disentangle this complexity analyzing each one of the considered cases, without over-simplifying their elements in the name of complexity reduction.

A precise strategy to organize the many empirical materials is mandatory to have a clear roadmap that helps to move forward. Of course, the research design clearly set the aims of the research and the means to get there, and two main guiding principles have been considered useful. First of all, how traditional SCOT works showed, the development of each DCT technology needs to be considered from a chronological and sequential point of view (Bijker, 1992, 1996). Starting from the design of the technology, and moving through its implementation, to finally reach its use seems a basic, but really important, element to give structure and organization to the presentation of the findings.

Then, the second guiding principle is "follow the actor". The primacy of relevant groups is clearly a cornerstone of the SCOT approach but is the ANT perspective that mainly defined this methodological rule. As stressed on other occasions across the contribution, this principle is a key one in defining the approach to the empirical field, but here works also as a reference for presenting the different materials.

Following this sequential description of the construction of DCT in Italy, the attention will land on the specific role of some of the relevant actors mentioned in the previous chapter but not largely explored, that is the privacy authority and local healthcare authorities. With respect to what has been written so far, the empirical materials coming from the users' reviews will be considered as well. It goes without saying that they are included in the section dedicated to the using phase of Immuni. Finally, the chapter would close with a portion dedicated to the role of healthcare authorities, preceded by some reflections on the relevant actors' views on the using of the DCT app in Italy, stressing some of its weaknesses. This last paragraph will start building some elements to answer the second research question, but this is a matter that will require still a fair number of pages.

1. The design of a digital contact tracing solution for Italy

1.1 The Government call

Between March 20th and March 21st, 2020, different Ministries from the Italian Government, along with members of the Istituto Superiore di Sanità (the main center for public health in Italy), people from WHO, and experts from the different Government's departments developed and discussed guidelines and strategies to tackle the COVID-19 pandemic. Among the covered topics, emerged the possibility to start designing and implementing a digital contact tracing tool. A few days later, between March 24th and March

26th, a fast call for contribution was released, asking for digital solutions for managing telemedicine, home assistance, and contact tracing during the pandemic. Shortly after, the Ministry of Innovation organized a task force of experts named "Data-driven working group in the Covid-19 emergency". The large group of experts was composed by 8 sub-groups with specific tasks. The two subgroups that were dedicated to DCT were the group number 6, named "Technologies for managing the pandemic", and group number 8, "Legal elements related to data management during the pandemic" (Ministro per l'innovazione, 2020b). The Ministry defined general activities for the two groups, as pictured in *Table 1*.

Table 1 - Task force groups dedicated to DCT and related activities

Group 6 - TECNOLOGIES FOR MANAGEING THE PANDEMIC	Group 8 - LEGAL ELEMENTS RELATED TO DATA MANAGEMENT DURING THE PANDEMIC
Activities: identifying possible solutions offered by digital technologies for emergency management and containment of the contagion, also based on a comparative reconstruction of the solutions adopted in the EU and non-EU contexts (UK, Germany, Singapore, China and South Korea) and proceeds to the evaluation, from the technological point of view and from the point of view of the impact on the purposes of countering the spread of the contagion, of the solutions proposed under the "Fast Call for technologies to counter the spread of Covid-19" promoted by the Minister of Technological Innovation and Digitization, the Minister of Economic Development, the Minister of University and Research and the Minister of Health.	Activities: proceeding with the analysis and mapping of the regulatory constraints for the use and sharing of personal data between public entities and between private and public entities, and prepares a strategy for guaranteeing fundamental rights and freedoms in the ordinary and emergency management of personal data, including through the reconnaissance and analysis of the strategies in place in European countries, as well as proceeding with the verification of the compatibility of the technological tools being evaluated by Working Subgroups 5) and 6) with the national system.

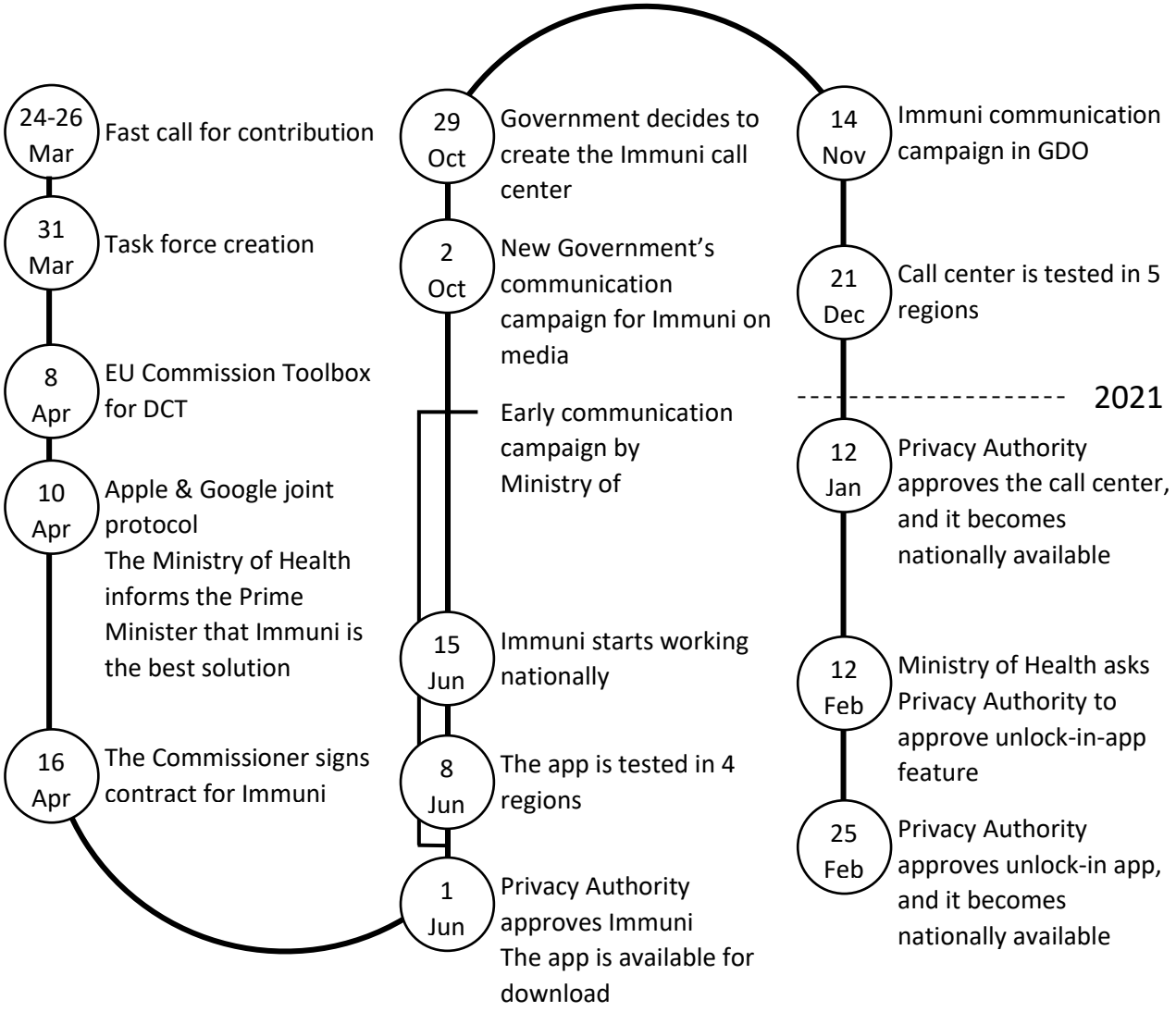
Source: (Ministro per l'innovazione, 2020e)

The official report of the group 6 tells that 319 technology proposals answered the call. After a general screening, only 15 of those had minimum technical characteristics, and then just five were somehow ready to be implemented. The sub-group scrutinized these 5 short-listed solutions through interviews (Ministro per l'innovazione, 2020d). While group 6 more attentively evaluated the technical dimension of the proposed solutions, group 8 focused on their legal aspects. The goal of both groups was to provide useful guidelines to Government's decision-makers for choosing which kind of technology to develop for DCT purposes.

Figure 1 works as a roadmap of the different steps that characterized the design and implementation of the DCT strategy in Italy that are now going to be analyzed. It includes some relevant elements of issues covered

in the previous chapter, such as Apple and Google involvement, and the EU guidelines release. Additional elements, such as the Government communication campaign and new features of the tracing process like the call center, will be mentioned and considered throughout this chapter.

Figure 1 - Timeline of Immuni development



1.2 The selection process to find the official DCT app

The activities within the task force groups did not seem to be too structured. *Interviews C*, a member of group 8 of the Government's task force that oversaw data protection implications of DCT solutions, explained that beyond the focus on the legal profiles related to privacy, no real priorities were indicated to the group by the political decision-makers. Furthermore, *Interviewee D*, another member of the same group, told that there were no real hierarchies within the group since just the figure of the coordinator was established.

The work was organized into sub-groups. Each sub-groups received some of the technological solutions that answered the fast call to carry out an assessment on their level of privacy protection. Initially, the work was

very focused on the evaluation of the different technological solutions, considering their strengths and weaknesses from a legal point of view. Then, the group had the opportunity to discuss more general principles.

With respect to group 6, that was asked to evaluate digital and technical features of the different tracing projects, *Interviewee A*, who participated in the group's activities, recalled how things developed within it:

> *I believe we started with the group on March 28th, 29th, and delivered the report on April 7th-8th, something like that.*
> *[…] We tried to operate in the shortest possible time, to ensure that in the shortest possible time there could be some help for the health service. [...] I must say that perhaps more work has been done beforehand. Work in the sense of sensitization, that is, in a very voluntary way, try a little to spread information about what the experiences abroad were, what had been done in other countries. So, we were trying to push our institutions to consider a contact tracing solution.*
> *In those 10 days, what we did, in an extremely dynamic scenario… now many do not remember but in that couple of weeks various changes occurred: before the federated contact tracing model [...] was decentralized, then within a few days, just as we were about to close the report, they switched to a centralized model, after a few days Google and Apple announced their protocol. [...] So on the one hand we tried to do something ... to hear at least someone, then we divided the work a bit, in short, to hear a little from these developers, organizations, structures that they had [submitted a technological proposal] ... above all to understand, beyond the single app, what were the logics they were following. For example […] CovidApp had a completely different approach than the others. So, a first element that we looked for, I repeat, in the speed that was imposed on us in those days… a first element was to say what are the possible approaches, which were not all the same. At some point, everyone decided to use Bluetooth, but it was not always the case, some, and in my opinion correctly, at least thought of adding GPS alongside Bluetooth to also have the absolute position, not just the position of relative proximity.*
>
> Interviewee A

Interviewee B, member of group 6 as well, confirmed that the group worked under high pressure and within a constantly evolving context. As largely described in the previous chapter, the announcement by Apple and Google shook the work and the considerations developed until that point. Therefore, the group needed to reevaluate its conclusions based on the ENF, and check whether it could match with the previous conclusions as well.

The interviewees who participated in the groups also recalled the main principles that guided the decision process on the best technological artifact to implement a digital contract tracing strategy in Italy, which has been clearly expressed also in the official reports of the two sub-groups (Ministro per l'innovazione, 2020c, 2020d).

1.3 Main discussed topics and selection criteria for identifying the official app

Interviewee C explained that the main issue that group 8 faced was the level of invasiveness of the various technological solutions proposed, in relation to the processing of personal data. They tried to understand what approach the various projects adopted, to then verify how coherent they were with the current regulatory system. The group's goal was not to favor the project that would guarantee complete anonymity. If that had been the case, the legislation on the protection of personal data would not even have entered the field, since anonymity guarantees that personal data is not processed. The group verified that the technological solutions were in line with the legislation, and that they went in the direction of greater protection of privacy.

Privacy and data protection were key for group 6 as well. Its official report says that "the selection of the solutions was therefore oriented towards full compliance with European laws and principles on privacy and data protection. The mechanisms and technical standards sought are therefore aimed at protecting privacy, transparency, and security in data management, exploiting the possibilities of digital technology to maximize the speed and capacity in real-time of response to the pandemic. [...] The implementation must be based on open source code, with secure and scalable backend services capable of managing hundreds of millions of registered devices, support services for cross-border interoperability, dissemination and adoption by of a critical mass of citizens" (Ministro per l'innovazione, 2020d, p. 6).

Besides privacy and data protection, group 8 shared other similar guiding principles in the selection, such as the just mentioned open-source feature of the proposed technologies. Furthermore, they largely valued the freedom of choice of users when interacting with the app and the fact that the DCT solution would be proportionate and limited in time (Ministro per l'innovazione, 2020c).

A largely covered issue has been the geolocation features of the contact tracing apps. *Interviewee B* explains that group 6 favored solutions that used Bluetooth and not GPS. However, as the excerpts from the previous paragraph may have suggested, not all the members strongly agreed on this point. Some reflections on the use of geolocation have also been published in the official report of group 6, mentioning especially the weaknesses of the Bluetooth technology. The report states that "based on the current technological constraints on some types of devices, in particular those employing iOS operating system [ed.: the operating system running on Apple products], proximity tracing just via Bluetooth risks not maximizing the probability of identifying all contacts, as it may not be able to intercept the signals coming from devices where the Bluetooth functions do not work in a coherent way for the purposes of the application. It is therefore considered appropriate not to exclude a priori the possibility that, under the condition of an informed and aware opt-in, the technological solution to be implemented may deal with some precise and limited geo-localized information, not aimed at reconstructing the paths but limited to specific places of potential contagion" (Ministro per l'innovazione, 2020d, p. 10).

The position of group 8 on GPS was more clear-cut: *Interviewee D* told that the apps which did not employ GPS were largely favored in the group's evaluation.
Later on, the political decision-makers decided to exclude any GPS features from the app (Ministro per l'innovazione, 2020b).

Another relevant element on which *Interviewee C* said that group 8 focused on was freedom of choice in the app use. The group discussed the possibility of making the solution mandatory for the population, concluding that it was an aspect to be firmly avoided. Furthermore, the group evaluated the chance of including benefits or advantages to encourage the adoption of the app, noting however that discrimination issues could arise.

With respect to group 6, *Interviewee B* reported that the level of readiness for implementation of the proposed solutions was another strong guiding principle.
Among the many that answered the call, two solutions seemed to meet the different criteria adopted by the two groups, the centralized solution named "CovidApp", and the decentralized solution called "Immuni". The groups suggested that the latter was more proper and more ready to forgo the implementation process, but the final word was up to the decision makers that finally indicated Immuni as the official Italian DCT app. On April 16th, 2020, the collaboration with Bending Spoons, the firm which developed Immuni, was signed by Domenico Arcuri, the Government's Commissioner for pandemic management (*ORDINANZA n. 10/2020*, 2020).

The selection process of the national DCT approach did not come without complaints or recriminations. *Interviewee I*, a member of the team that presented the second-placed CovidApp, stated that Immuni was not a better solution, also mentioning some opaque mechanisms behind the Government decision, as also done by *Interviewee H* who was in the same team.

> *We finished second, you should consider that in February [ed. probably referring to March 2020, when the fast call of the Ministry of Innovation came out] the offer [ed. their DCT solution] was much more primitive, but there were already Android and iOS [DCT systems] working, always with the logic of the backend, and it was presented [to the evaluating groups]. Of course, it was not as refined as the one we have now. Unfortunately, the logic of the sheet of paper won, Immuni showed up with a sheet of paper and they won. At the time they didn't have a demonstration, not even a mock-up, but only a printed presentation. A lobbying logic has won against a logic of providing a service, a very political matter...*
>
> Interviewee I

It may appear that this section of the chapter did not actually cover the design of the DCT solution for Italy because it has been mainly about the activities of the two groups that ended up suggesting the selection of Immuni. However, the described selection process carried out by the members of groups 6 and 8 of the Government's task force worked as a sort of design process or – more properly – a definition process of the

DCT technology. Based on the set of values and principles that have been described, namely data protection, user autonomy, use of GPS, etc., the two task force groups did not develop a technology from scratch, but evaluated already existing ones, trying to find the one that was more compatible with their perspective. It was not a matter of creating an artifact or a project based on a set of values and aims, but it was about selecting it from the 319 projects that answered the fast call. The design process by the national institutions happened *ex post*, but in the end had a similar impact: having a technology with some specific characteristics that could reach the tracing aim. Immuni met the standards that were set by the members of the groups, so it was selected, while other projects were rejected. So, it is not that interesting from a sociological point of view to study how Bending Spoon developed the Immuni script. *Interviewee G*, who participated in the early design of the Immuni proposal to the Government, recalled that in the initial phase some inspiration came from the DCT solutions employed in South Korea and Singapore, and that the use of GPS was considered useful. However, what matters, in the end, is that Immuni's characteristics are compatible with the Italian institutions' values and aims. Therefore, it is relevant to consider the selection process to understand how DCT has been initially defined in Italy, before reaching its implementation phase.

2. The implementation of the selected DCT solution in Italy

The implementation of Immuni was quite straightforward from a technical point of view. As already reported in the previous chapter, since Immuni relied on the ENF, the lower level, which mainly involved the Bluetooth communication protocol, was managed by Apple and Google. Therefore, the tasks for Bending Spoons were not too complicated and consisted of implementing the interface of the app and additional features whether requested.

However, before launching the app, the approval of another relevant actor was required, namely the national data protection authority.

On June 1st, 2020, the privacy authority released a document that stated that "the processing of personal data carried out in the context of the Alert System is legitimate and proportionate as the rights and freedoms of the data subjects are respected and is also accompanied by adequate prevention and diagnostic measures aimed at facilitating the care of infected people by the National Health System and the early identification of new foci of infection. This, ensuring, in particular, transparency, correctness and security at every stage of processing, in relation to the high risks it presents for the rights and freedoms of the data subjects" (Garante per la protezione dei dati personali, 2020, p. 6).

Furthermore, the authority stressed the centrality of the voluntariness of users in interacting with the DCT app. Such voluntariness needs to be respected in "all parts of its functioning: the download, the installation, the configuration, the activation of the Bluetooth technology, the loading […] of a positive result of the swab, the collection of the different categories of analytics in the phases in which the treatment is divided, the consultation of the trusted doctor after receiving an alert message on the risk of having come into close

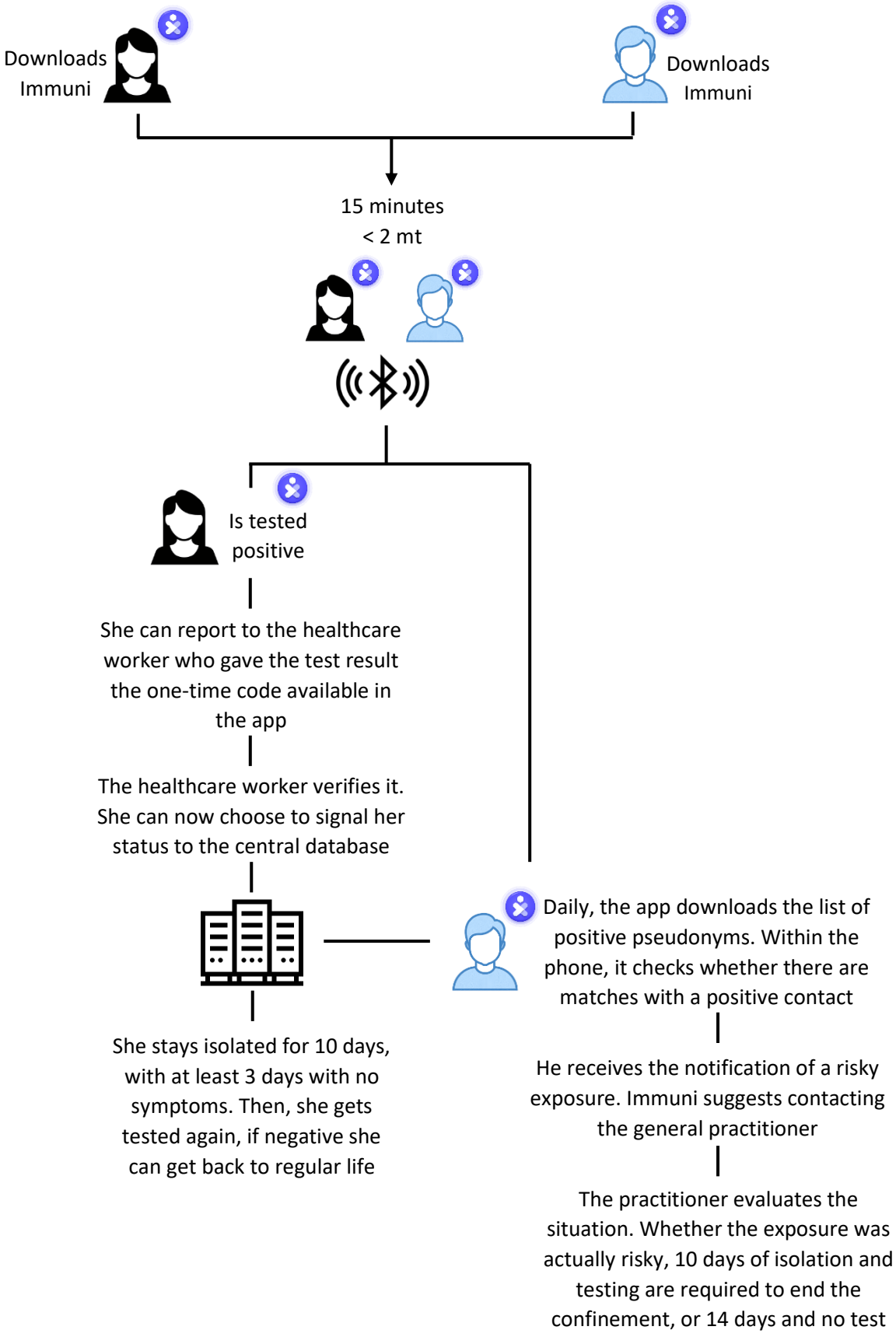
contact with subjects who tested positive, the uninstallation of the application, etc. " (Garante per la protezione dei dati personali, 2020, p. 7).

Then, the national privacy authority also mentioned the centrality of the use of pseudonymized data, the fact that DCT solutions come with the risk of many fake positives, and the need to manage data for a limited amount of time and delete them when it is not useful anymore. The authority also considered the role of Apple and Google, stating that: “the use of the Apple/Google Framework assigns them a mere role of technology providers without implying any processing of personal data per se”, noting however that "in the impact assessment instead [their] role is not sufficiently clarified” (Garante per la protezione dei dati personali, 2020, p. 13).

Finally, in the early days of June 2020, Immuni was ready for release. It was initially tested in four regions for a week, then, on June 15th, it was available to all the citizens (Rai News, 2020).

On the release date, the digital tracing procedure implemented with Immuni worked as pictured in *Figure 2*. Two people having the app and spending at least fifteen minutes at less than two meters distance, when one of the two is tested positive, s/he could enter the tracing protocol designed and implemented for Immuni. The person who tested positive can get in touch with the local healthcare authority to unlock his or her positive status on the app. Then, s/he can choose whether upload the positive status on the central database. Once the pseudonymized status is on the central database, the device of the person s/he met would find it on the list that has been downloaded daily, and the app would notify about a risky encounter. The user that experienced the risky encounter can decide whether to contact the general practitioner (GP), who will later evaluate the situation and act accordingly, suggesting a test, isolation, or something else.

Figure 2 - How the digital tracing procedure works with Immuni



After the implementation of the app, the using phase starts. The upcoming section specifically focuses on it through the eyes of the actors who were mainly involved in it, starting with the users, and then moving to other relevant actors. The section also considers the healthcare authority's role, another pivotal element that has already been mentioned throughout the development of this work and should be clear from the description of how the tracing procedure was initially designed in Italy.

3. The official Italian contact tracing app in use

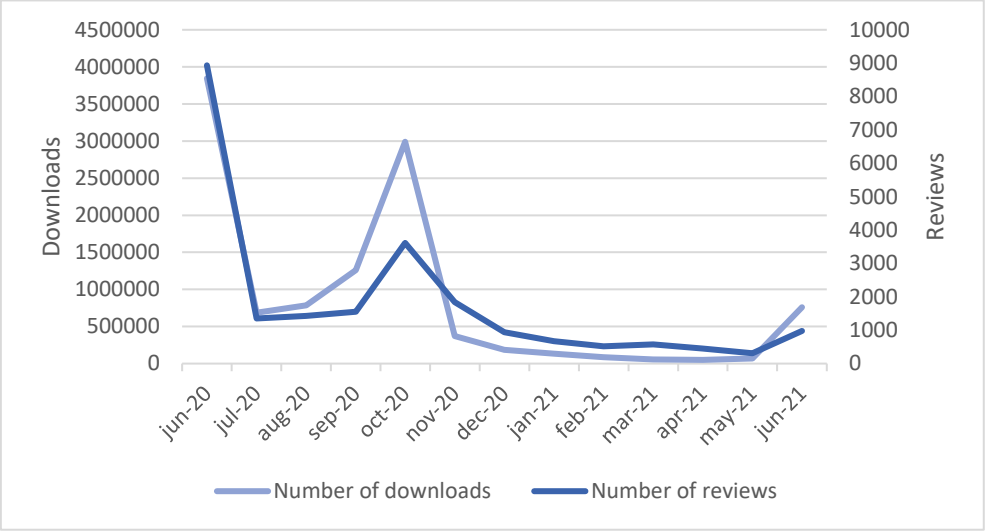
The reason why it is useful to look at the using phase through users' generated contents has been already presented in the methodological chapter. However, an interesting element could be added to increasingly strengthen this research strategy. In its official document which ultimately authorized the release of Immuni, the Italian privacy authority explained how, in the evaluation process of the intervention, it is key to gather and consider users' opinions on the app and its related digital contact tracing procedure (Garante per la protezione dei dati personali, 2020). The following pages analyze the users' reviews posted on the Google Play Store under the Immuni page, from June 2020 to June 2021. First of all, more descriptive information is reported to have a general understanding of how the users' generated contents spread throughout the year. Then, the findings of the automated analysis through Python are present. Finally, the deeper focus through the manual thematic analysis closes the findings emerging from the analysis of reviews.

After having considered the use of the DCT app in Italy through users' reviews, the paragraph also covers the opinions and perspectives of the interviewees. Since most of them have been involved in the design of this technology, their view on the same technology in use is a relevant one that would add interesting elements in the understanding of the whole tracing process in Italy.

3.1 A descriptive snapshot of user's reviews

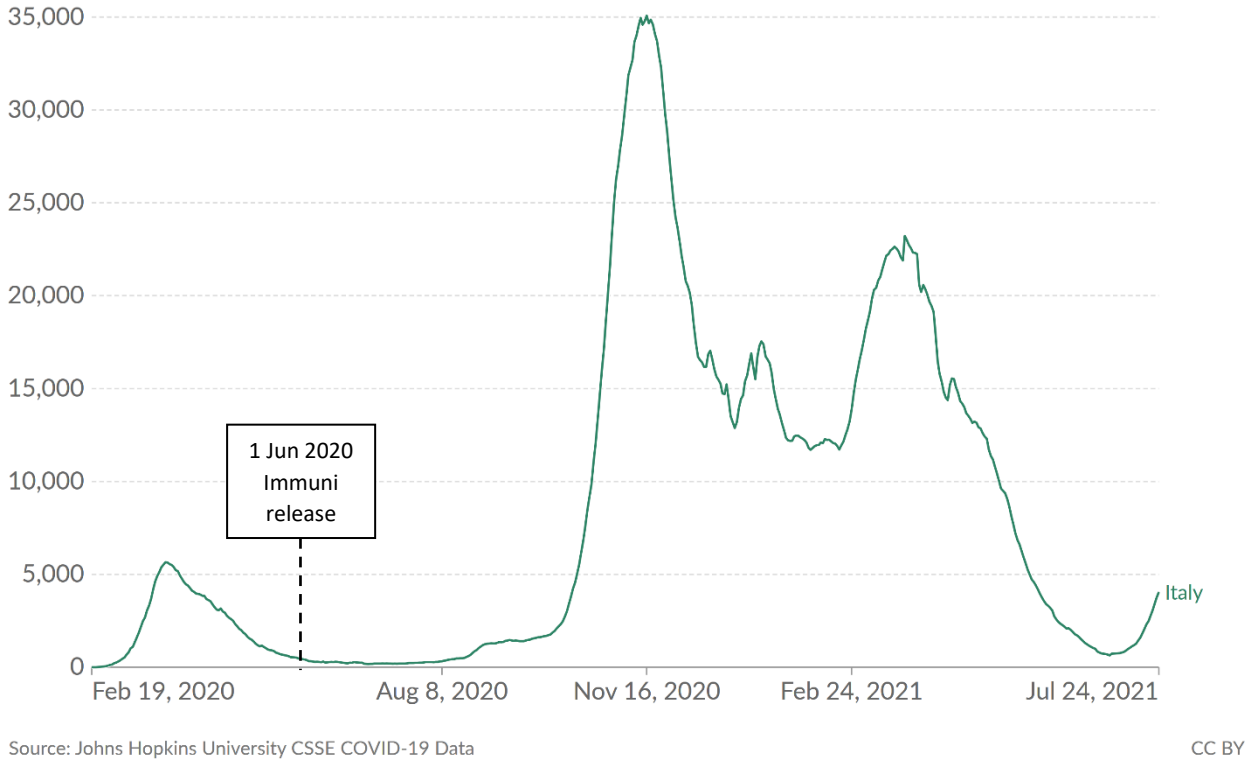
The first relevant consideration with respect to reviews is related to how they distribute within the considered time frame. *Figure 3* shows both the number of reviews posted each months and the number of downloads of Immuni. The highest peak for both metrics is registered right after the launch in June 2020. Another significant increase in the number of reviews is registered in October 2020. On both occasions, after the peak registered during a month, the number of downloads and contents posted online significantly decreased.

Figure 3 - Number of downloads and reviews by months



It is quite straightforward to identify the reason that explains the first peak in downloads and the related number of users' reviews since the app was launched in June 2020. Conversely, justifications for the October peak are less evident. A first explanation could be related to the so-called "second wave" of COVID-19 contagion in Italy, meaning that with a rising number of coronavirus cases, people downloaded and commented more on the application with respect to previous months. However, this perspective only partially explains this second peak. As *Figure 4* shows, the number of COVID-19 positive people raised around October 2020 but kept growing also in November when it reached its maximum. Conversely, *Figure 3* and *Figure 4* show that the number of downloads and reviews dropped significantly in November 2020. Therefore, another reason was probably responsible for this trend. It can arguably be found in a strong communication campaign issued by the Government on many national media and oriented towards promoting Immuni download and use, as reported by news outlets of the time (ANSA, 2020). *Figure 1* at the beginning of the chapter pictures this communication campaign in the timeline of the app development, as it happened around the same period of the registered peak in downloads and reviews.

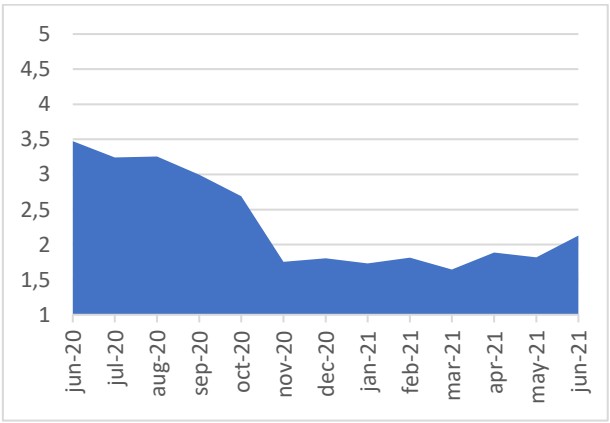
Figure 4 - Number of positive people in Italy throughout the months



Source: Our World in **Data** *https://ourworldindata.org/coronavirus/country/italy?country=~ITA (last accessed: 12/10/22)*

Next to how reviews and downloads distribute across the considered period, another metric can be considered to define a more complete descriptive picture of users' generated content on the Google Play Store. *Figure 5* shows the average ratings that users attributed to the Immuni app. It is interesting to notice how October 2020 is once again a pivotal period with respect to the considered issues. The plot depicts how during that time the average rating of the app dropped by almost 1.5 point and never recovered.

Figure 5 - Average ratings of the app by month



It is useful to look more closely at the users' ratings since the average offers only some elements of the whole phenomenon. As *Figure 6* presents, the average values originate from the large majority of 1-star and 5-star ratings posted by the users. Furthermore, the trends of the highest and lowest ratings are quite similar throughout the months. As depicted in *Figure 7*, top ratings were a little more frequent right after the release, while bottom ones increased more consistently around October 2020.

Figure 6 - Share of reviews with different ratings

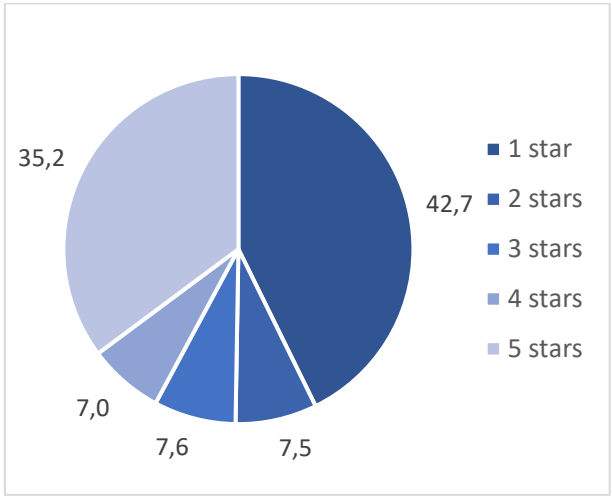
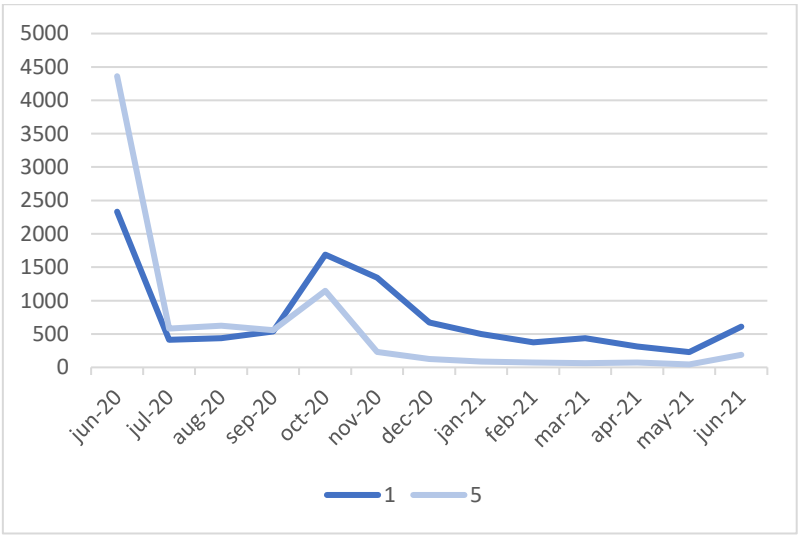


Figure 7 - Number of reviews with 1- or 5-star ratings throughout the months



3.1.1 Interpreting the data

From the descriptive materials presented so far, it emerges that the largest share of attention by users, both in the number of downloads and posted reviews, was registered right after the launch of the app in June 2020. Another spike in the attention towards the app happened around October 2020, arguably due to a Government's promotion campaign. Through the analysis of the users' ratings, it emerges that the audience is strongly polarized, with almost 78% of the users who posted a review evaluating the app as either 1-star

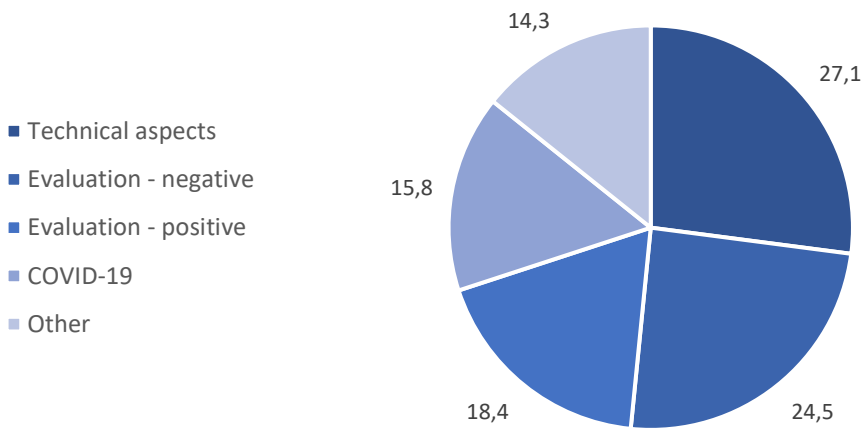
or 5-stars. The average rating throughout the considered period decreased strongly around October 2020, from when the 1-star evaluations surpassed the 5-stars and kept this trend until the end of the studied window.

3.2 Zooming in: most recurrent topics in Italian reviews

The snapshot taken with the descriptive statistics is a useful initial approach to the users' reviews, but it does not offer too much relevant information to understand what users think about Immuni. The automated analysis of all the reviews is an additional step in this direction. By running the basic natural-language processing script on the 24270 scraped reviews, a large number of trigrams and bigrams emerge. The top20 most recurrent bigrams have been selected and are available in the *Appendix*, as well as the top30 bigrams. The top20 trigrams have been manually classified into five categories: "Technical aspects", "Evaluation – negative", "Evaluation – positive", "COVID-19", and "Other". *Figure 8* pictures the share of each category with respect to the group of top20 most recurring trigrams and their average users' ratings.

The "Technical aspects" category groups trigrams that deal with technical dimensions of the technology in use. It is the case of the largely represented trigram mentioning the Google Play Store, the one on battery draining, or those referring to the notification system of the app. More than one-third of the most recurring trigrams is then related to the evaluation of the app. Several users expressed negative evaluations with respect to Immuni, saying that it is useless. Conversely, the "Evaluation – positive" category contains the trigrams that express support and appreciation toward this technology. The "COVID-19" category groups those trigrams that refer to experienced encounters with positive people. Finally, the category "Other" contains three additional most recurring trigrams that did not fall in the previous categories. These trigrams refer to unclear elements in the DCT procedure through the app and to the possibility to make Immuni download compulsory for the Italian population.

Figure 8 – Share of most recurrent trigrams categories in Italian reviews and related ratings

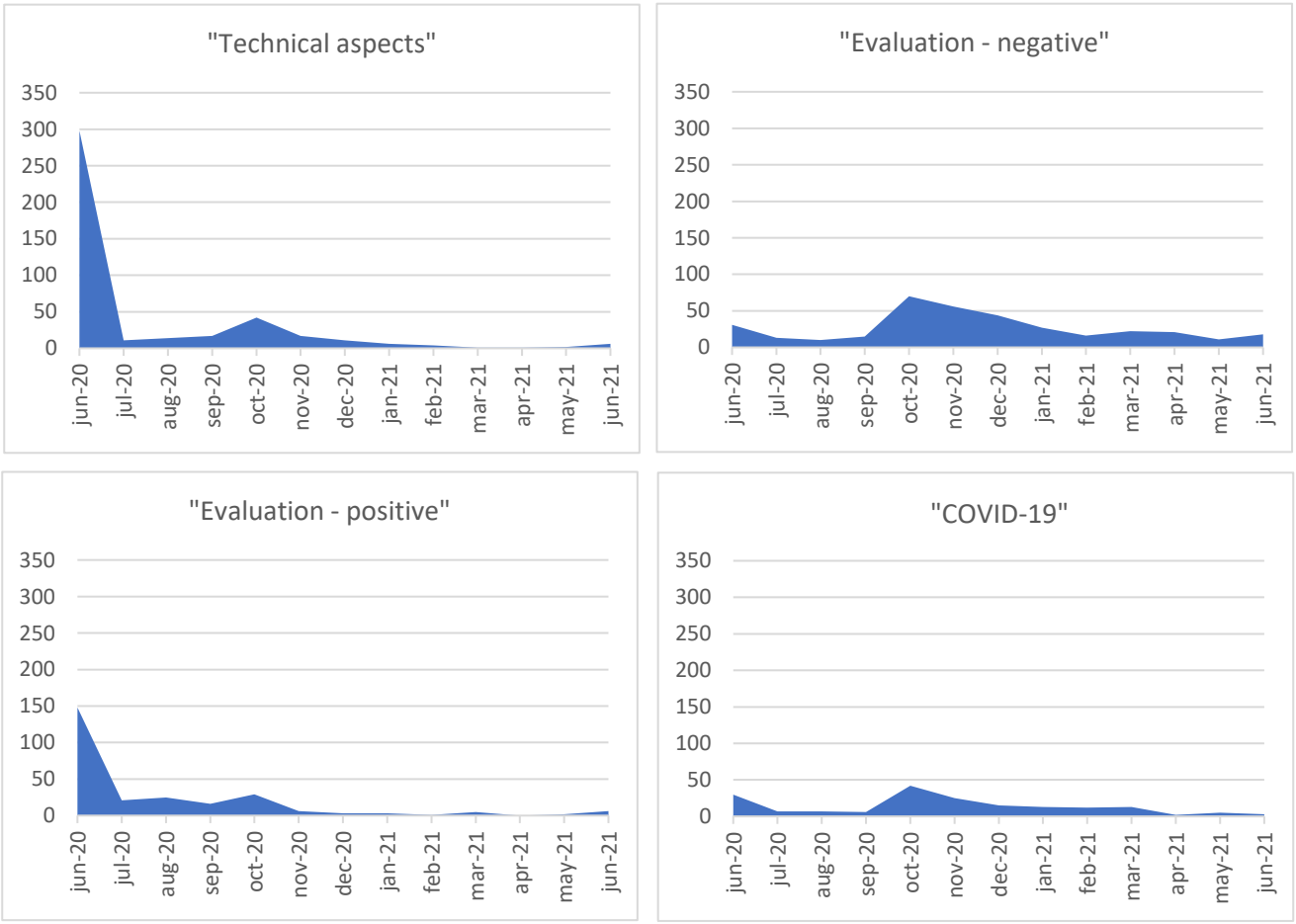


Average ratings for each category

Technical aspects	1.7
Evaluation - negative	1.1
Evaluation - positive	4.1
COVID-19	2.0

Additional relevant information could emerge from considering how these different trigram categories develop across the considered period. In *Figure 9* the trigrams of each category are pictured based on the month when they were posted, showing the different trends of the considered categories.

Figure 9- Number of reviews per trigrams category throughout months



3.2.1 Interpreting the data

Contrapositions in the audience somehow emerges also by *Figure 8* where a significant share of most recurring trigrams in reviews both indicate positive and negative evaluations of the app. The most recurrent current group of trigrams is however the one related to technical issues.

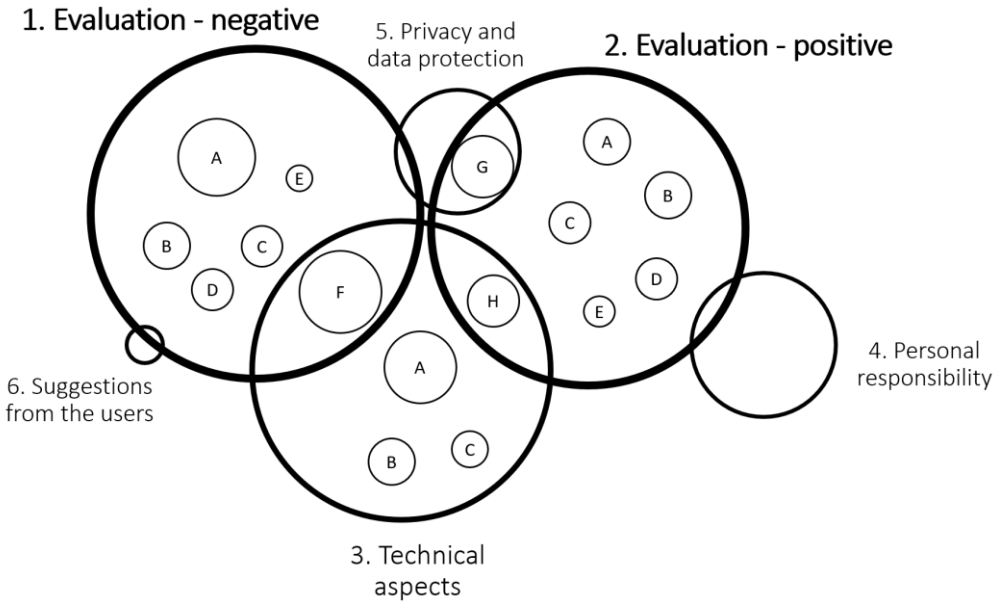
By considering trigram categories across the analyzed period, it interestingly emerges that the two peaks that were mentioned in the previous sections replicate once again. While the "Technical aspects" and the “Evaluation - positive” categories are more represented in reviews posted right after the launch, the other two categories registered higher numbers around October 2020. With respect to the “Evaluation - negative” category it could be explained by the already mentioned communication campaign to promote Immuni: new, and arguably more skeptical users, get in touch with the app after the promotion by the Government and they do not find it aligned with their expectations. Conversely, the “COVID-19” trigrams are more popular in October also because of the increasing number of positive people who were also registered by the app.

3.3 Zooming in even more: thematic analysis of most liked Italian reviews

The manual thematic analysis of the 100 most-liked reviews is the closest look available in this research on the contents posted by users. *Figure 10* shows the most recurrent themes based on the coded materials, picturing how they intersect with one another and the most relevant elements that constitute them. Intuitively, a larger circle means that the theme or element was more recurrent across the analyzed reviews. The diameter of each circle is equal to the number of coded excerpts divided by ten.

The paragraph develops by exploding the three larger themes, reporting some examples of relevant elements within them that will help better understand users' opinions towards Immuni.

Figure 10 – Map of themes and elements in Italian reviews



1 Evaluation - negative	2 Evaluation - positive	3 Technical aspects	4 Personal responsibility
1 A Healthcare authorities	2 A Easy to use	3 A Battery of the phone	5 Privacy and data protection
1 B Unclear elements	2 B Recommend the app	3 B Doesn't work on old phones	6 Suggestions from the users
1 C Test	2 C Benefits in managing the pandemic	3 C Camera and position permissions	
1 D Useless app	2 D Good idea behind	*F Errors & bugs*	
1 E Economic impact of the operation	2 E Useful & nice	*H Technical features*	
F Errors & bugs	*G Data protection*		
	H Technical features		

3.3.1 The "Evaluation - negative" theme

Despite a highly significant difference between the three larger circles is not visible, the most recurrent one is negative evaluation. It is a category that recalls one of the trigrams' categories introduced in the previous section (i.e.: Evaluation – negative) and contains a portion of reviews that express negative opinions on the app. The most discussed topic among users when writing about negative elements of the app are Immuni's technical problems, errors, and bugs. As group F shows in *Figure 11*, these problems lie across two major

themes: the negative evaluation and the technical aspects. Users complain about several software technicalities that did not make their experience with Immuni run smoothly.

> *Despite having location services active, the app refuses to work on my huawei / honor 9x. It's as if he can't get the rights to the GPS. It doesn't work the same way on my wife's cell phone either, and what's worse, it doesn't even say why. Maybe it needs to update the OS, but there are no updates available for our phones.*
>
> Posted on 03/06/2020, 1 star

> *Today, 13 Sep, the Immuni app tells me: "last exposure control carried out on September 1" ... Mobile phone always on with bluetooth always on, wifi and gps (even if not influential) always active ... So what should I do? If the app doesn't contact servers for nearly 2 weeks it doesn't seem to make much sense to me. Or is there something I didn't understand?! Idk.*
>
> Posted on 13/09/2020, 2 stars

An interesting element in the negative evaluation theme is related to the experience with healthcare authorities (1A in *Figure 11*). Several reviews complained about difficult relationships with the local healthcare authorities, who, as *Figure 2* showed some pages ago, were in charge of activating the whole tracing procedure through the app.

> *I tested positive. I would have liked to report the positivity, but the procedure requires that I have to be contacted by telephone by an authorized health professional. Nobody knows who he is. Nobody contacted me.*
>
> Posted on 05/10/2020, 1 star

> *My husband and I tested positive for the swab on 14 and 18 October. No health worker who contacted us knew how to activate it.*
>
> Posted on 19/10/2020, 1 star

Strictly related to issues with healthcare authorities, in expressing negative evaluations of the app, some users also stressed how they experienced problems also with the COVID-19 test signaling-procedure of the app (group 1C).

> *I know several people who have tested positive for the covid and have never had the opportunity to report their positivity on the app.*
>
> Posted on 16/02/2021, 1 star

Furthermore, when expressing a negative evaluation of Immuni, some users shared opinions about the fact that it is not that clear how the app works (group 1B) and about the fact that the app looks useless (group 1D).

It is not clear what it can be used for. It is very poorly explained. In Ponza in the week from 30 August to 6 September I received more than one notification with a Covid icon. But it is not clear what I could have done.

Posted on 11/09/2020, 1 star

Despite having the certainty of having come into contact (due to work) with positive people, I never received any notification. Completely useless. Like all things in Italy, in theory they work fine but in practice they don't.

Posted on 13/03/2021, 1 star

While a smaller portion of users raised perplexities about the way public money was implemented to develop Immuni (group 1E).

I consider it a waste of public money as usual.

Posted on 04/11/2020, 1 star

3.3.2 The "Evaluation - positive" theme

The second most recurrent theme is "Evaluation - positive". Like the previous one, this theme resonates with a trigrams' category of the previous section (i.e.: Evaluation – positive). Moreover, still like the previous theme, the positive evaluation one shares a relevant element with the theme that deals with the technicalities of the CTA. Also reacting to other users' negative comments, some people shared their positive experiences with some of the technical features of the app.

I have a smartphone with Android system from 2016. I was afraid, given the comments, that the app would not work or that it would drain my battery quickly, since it is not exactly new. None of that. The app works fine and in the background. It doesn't have to be opened every time. Just keep geolocation and bluetooth turned on.

Posted on 06/10/2020, 5 stars

However, in the positive evaluation theme, the most recurrent element is data protection (group G), which is shared with the minor data protection and privacy theme. Users express their opinions about the level of data protection and privacy that Immuni guarantees.

Inside the app there is a complete guide and a substantial apparatus of information on the management of personal data (the app does not know who you are, where you are and what you do).

Posted on 02/10/2020, 5 stars

Furthermore, appreciation is shown due to the interesting idea of digitizing the contact tracing procedure, a pivotal element for getting out of the pandemic more quickly (groups 2C/2E). Some users also considered the app easy to use (group 2A) thanks to its intuitive interface.

The app looks good: the interface is clear, the access is simple and instant. Just declare the region and province and you are immediately ready.

Posted on 02/09/2020, 5 stars

Fundamental for one's own survival and that of others. If everyone installed it, the pandemic would end in a matter of months.

Posted on 19/10/2020, 5 stars

Graphically speaking it is a bomb. There are very few Android apps that have such a modern, clear look, and with detailed information. Good job!

Posted on 01/06/2020, 5 stars

The positive evaluation of the app makes some users also encourage their pairs to download Immuni and take part in the digital tracing procedure (group 2B).

since I am not a person who sees ghosts everywhere and spends days hunting for imaginary monsters, it is absolutely worth downloading for our safety.

Posted on 15/06/2020, 5 stars

3.3.3 The "Technical aspects" theme

Coming to the third most recurrent theme, “Technical aspects” has been already mentioned in the previous two paragraphs, as well as in the analysis of trigrams. With respect to its elements that have not been mentioned yet, several users posted reviews dealing with the battery life of the phone (group 3A). It may look like another highly specific issue, but it is an informative one. Along with the reviews related to the “doesn’t work on old phones” category (group 3B), they show that Italian users experienced some issues due to the probably outdated devices. This is plausible also because some other users post that they were experiencing no problems with respect to the battery of their phone, so the problem should be related also to the device and not just to the app.

The bluetoot is always active even if you say 'low', the question is but did you think that an average mobile phone with an average daily use can make it to the evening? My S8 is already down around 7pm. Bottom line, I uninstalled.

Posted on 10/09/2020, 2 stars

It doesn't drain this whole battery at all.

Posted on 06/08/2020, 5 stars

I find it absurd, however, that it cannot be installed on devices with an Android system starting from version 5 like most apps! Not everyone can afford a latest generation mobile phone! It was not possible to download the app for this very reason on my mother's cell phone, who is in her seventies and therefore the category most at risk and to be protected.

Posted on 15/06/2020, 3 stars

An additional technical element that is worth considering, is related to the use of GPS (group 3C). Some users complained about the fact that the app requires them to have it on despite not using it. The review posted below, and similar ones, show a good level of understanding of the app and sensitivity towards personal data. Similar reviews are few and isolated, but yet interesting ones.

> *Even if it doesn't use location data, it won't work if GPS is turned off. It is really annoying to have to leave the GPS active (giving the position to other apps) even if it is not necessary for the immuni system to work. I don't think I'm the only one who turns off the GPS when he's at home and forgets to turn it back on when he's out and about, thus making the app useless (because it deactivates).*
>
> Posted on 02/10/2020, 1 star

3.3.4 Other minor themes

Besides these three similarly frequent major themes, some of the smaller ones should be mentioned as well. The theme "personal responsibility" incorporates elements of reviews related to users stressing how Immuni and the success of a digital contract tracing strategy are strongly connected to the personal choice of users in downloading and engaging with the app, which in the eyes of some is an issue.

> *Let's do it for Italy, beyond the political creed. We try to be collaborative!*
>
> Posted on 03/06/2020, 4 stars

> *Unfortunately, as it is, it is a useless app, too conditioned by the choices of individuals: you can decide whether to download it or not, you can decide whether or not to consent to notifications, if you keep Bluetooth disabled cannot work ... and so on.*
>
> Posted on 11/06/2020, 1 star

The "privacy and data protection" theme includes reflections on the fact that people should not worry about giving little data to Immuni when they daily engage with tech corporations' services that are reportedly more intrusive. No relevant reviews seem to address the issue of privacy violation by Immuni. Conversely, it is interesting to consider how reviews expressed a negative evaluation of Immuni's data protection policies because they considered them too strict.

> *Google, Facebook & C. know everything about us and are there still naive people who hesitate before installing it because they fear for their privacy? Simply ridiculous!*
>
> Posted on 01/06/2020, 5 stars

> *The privacy law is increasingly proving to be a boomerang. It is a huge limitation that we have foolishly and masochistically imposed on ourselves, which makes it difficult even to manage a serious epidemic like this. It needs to be drastically changed before it does more damage.*
> *The app is very well done and simple to use. In my opinion, however, it will never be reliable, precisely for the protection of privacy, because it lets you choose whether to share your codes or not.*
>
> Posted on 02/06/2020, 4 stars

With respect to the “suggestion from the users” theme, just a few users (7) among the top100 liked reviews engaged in constructive suggestions to developers. The reviews falling in this group contain requests for additional features in the app, such as counters of how many people are using the app at a certain moment, lists of the number of contacts - either risky or not - registered in previous days, or some general additional statistics on the pandemic development. In general, while offering suggestions users complained about the fact that the app is too "silent" and not largely "engaging".
Furthermore, a couple of users suggested also that the app should be mandatory for the Italian population.

> *I just wanted to point out to the developers that it is an excessively \ "silent \" application, it would be very appropriate, in my opinion, a minimum of interactivity. For example, I would very much like to have the number of contacts stored on my device. So as to have an example of the effectiveness of the App !!*
>
> Posted on 14/06/2020, 3 stars

3.3.1 Interpreting the data

As said at the beginning of this section, the manual thematic analysis of a selection of users' reviews is the closest look at their opinions carried out in this research. This closer picture confirms some of the elements of the previous broader snapshots.
First of all, the most represented themes in the analysis of popular reviews were also present in the analysis of the general database, namely the technical aspects categories and the negative and positive evaluations. These three themes were almost equal with respect to the coded elements, and the "Technical aspects" theme intersected both the negative and the positive evaluation ones, which instead were obviously separated. Therefore, quite strong user polarization emerges once again. Such polarization is even more visible when considering some technical features of the technology, like the impact on the battery life of the phone. Some users lamented strong battery draining when downloading Immuni, while others reported none. As already mentioned, these issues are arguably related to the fact that some Italian users do not have so up-to-date mobile devices, as also shown by some reviews commenting on the fact that Immuni does not run on certain old phones. Opposing views among users also emerge on the fact that, to some users, the app appeared easy to use and clear, while for others its use and features were more complicated. Furthermore, privacy and data protection were also discussed in both senses. In the eyes of some users, Immuni largely guaranteed users' privacy, while for others privacy and data protection were not tackled in a proper way. Surprisingly, users sharing this latter position did not complain about privacy violations and possible data breaches but argued how the design privacy protection policies for Immuni were too strong and could jeopardize the app's success and usefulness. In general, with respect to other topics, data protection and privacy were not largely discussed. The way privacy was tackled by users strongly differs from what was presented at the beginning of the chapter with respect to the concerns and worries of those actors that were involved in the design and implementation of the app.

Concerning minor themes, very few users offered suggestions for app development, showing how active user engagement was very marginal within the Immuni using phase. Conversely, users stressed how pivotal the role of each individual was to bring the app, and therefore the whole DCT strategy against the pandemic, to success.

One last interesting aspect that is important to stress in the negative evaluation theme is related to the role of healthcare authorities and the difficulties that users experienced in interacting with them. The relevance of such an issue is also confirmed by the list of the top30 most recurrent bigrams, which is reported in the *Appendix.* Among other elements already considered, the words "healthcare operators" emerge, showing how the healthcare authorities' issue has been largely discussed in reviews across the whole dataset. This element, as well as the one related to difficulties in uploading test results on the app, is strongly related to a pivotal element that will be better discussed soon, getting back to the interviews of relevant actors involved in the design of the app.

3.4 Relevant actors' views on Immuni's use, but mainly on the lack of thereof

As already stated, the DCT technology in use should not be considered just from the perspective of the users that decided to review it online. When reflecting on the use of Immuni in Italy, many interviewees offer interesting and broader considerations on the weaknesses of the whole DCT strategy that prevent the app's large diffusion. As *Interviewee F*, who participated in the development of the DCT protocol at the international level, put it: "certainly there was a low adoption, much lower than hoped". *Interviewee B*, member of the taskforce group 6 on technical elements of DCT, identified two dimensions that contributed to take the DCT strategy away from what was originally planned: the communication strategy and the organizational infrastructure. On these two elements there is a quite broad agreement among interviewees that they prevented a proper development of the technology's use phase.

With respect to communication of Immuni, *Interviewee C*, member of the taskforce group on data protection and privacy, argued that the problem was not mainly related to the institutional or promotional communication, but also to the wrong narratives that developed around the project on the media. *Interviewee D*, who was as well part of the privacy group, added that the way Immuni was presented by the media was highly superficial, which, as stated by *Interviewee E*, one of the scholars who participated in the development of protocols, wrongly framed the project as a decision to be made between data privacy or health protection. The same interviewee also argued that "some policy makers did not buy in the app as a valuable solution against the virus, which ultimately meant that a proper institutional communication campaign was not developed". The lack of a strong communication strategy was stressed also by *Interviewee G*, one of the early developers of Immuni, who considered the "empty" communication space of the two/three weeks after the announcement of the app as a huge damage to the success of the app since it was filled by wrong narratives on media and by opposing politicians.

Concerning the other problem related to the organizational infrastructure, the agreement by different interviewees is even broader probably. *Interviewee F* and *Interviewee E*, who both participated in the definition of international tracing protocols, explained how the issue with DCT was not related to the digital solution but to its non-digital components.

> *I don't think the problem was in the technological solution, which in fact in my opinion was a success for how it was developed and deployed, in the sense that it became available in such a short time. The problem is more, for example integration. That is, in the sense, how widespread the application has spread, how much health systems have also supported it.*
>
> Interviewee F

> *What did not work in Italy was that the non-digital part of the healthcare response chain linked to the app failed. An app was intended to be part of a supply chain, and a supply chain is largely non-digital. In a sense, then, what has failed is the non-technological component of the system.*
>
> Interviewee E

Similarly, *Interviewees A* and *D*, from the Government taskforce, *Interviewee E*, who worked on the protocols, and *Interviewees L* and M, the two computer science scholars, argued that the main issue emerged with respect to the technology's integration within the local healthcare authorities' tracking systems. A lack of integration that significantly impacted the use of the digital tracing solution. How *Interviewee C* puts it, when the adoption rate of the app seemed to increase significantly between September and October due to the fear of the so-called second wave, news of problems related to reports and activation of the app by healthcare personnel was largely spread among users and it contributed to discourage adoption. Stories related to the healthcare authorities or GPs not knowing how to deal with Immuni spread also on media, which contributed to increase the disbelief in Immuni, as the interviewees argued (Angius & Zorloni, 2020; Zorloni, 2020).

Interviewee G further elaborated on this issue, explaining how the problem related to the use of the app, or lack of thereof, by local healthcare authorities and GPs is related to the design of the functioning process of the technology itself, which has been pictured in *Figure 2* in the early pages of the chapter.

> The approach was conceptually wrong, it was thought that GPs could upload that data, and they were never trained by anyone. It was thought that it was enough to give this commitment to the Regions, and then to the ATS and ASL (ed.: local healthcare authorities), but they didn't give a s**t about anyone.
>
> Interviewee G

It has been shown in previous pages how users raised concerns about the relationship with healthcare operators. Furthermore, the interviews showed how they played a pivotal role with respect to the general deployment of the Italian DCT strategy. Therefore, it could be useful to develop a closer focus on the local

healthcare authorities' activities with respect to Immuni and DCT strategies, relying on the materials gathered through interviews of some professionals and the visit to one of their headquarters.

3.5 The local healthcare authorities, a very relevant actor

The local healthcare authorities in Italy have been among the main actors that initially needed to face the increasing number of COVID-19 patients. How the standard tracing procedure works has been explained in the early pages of this contribution, where it has also been described how the COVID-19 pandemic quickly overwhelmed this kind of approach. *Interviewee N_1*, a professional of a healthcare authority located in Northern Italy, recalls how, especially with the so-called second wave, happening in October-November 2020 the manual tracing system collapsed due to the high numbers of patients and close contacts:

> *[With] the second wave, when we opened everything, each person […] attended leisure activities, like gyms, sports activities or schools, each case brought with him/her 20-30 contacts that were all to be called. So, we did the math, in the golden periods even more than 1000 reports a day arrived throughout the territory, multiplied by 20, it is mathematically impossible that a system can hold up. […] The operators were unable to manage and carry out the task of precisely identifying, I don't just mean contacts, but very often also to identify people who could be… who were positive.*
>
> Interviewee N_1

This overwhelming number of positive people and related contacts was one of the elements that a DCT solution like Immuni should have helped manage. However, it has already been reported in the previous paragraph that the healthcare authorities did not largely rely on it. The interviews with the professionals confirm that. The representatives from the two authorities marked the official DCT solution for Italy as useless and completely marginal mainly for two reasons. On the one hand, due to the way it has been designed, it does not provide any relevant information for the tracking activities of the authorities. On the other, the very low usage rate made it pointless with respect to the high numbers of positive swabs that the authorities were able to register.

> *Look, unfortunately, Immuni did not play any role, because it was precisely in the characteristics of Immuni not to be able to transfer data, because satisfying privacy has always, let's say, guaranteed the non-collection of information. Therefore, not being able to get information from Immuni, did not allow to use it.*
>
> Interviewee O

> *I would say that it has not brought any benefit. [...] There was a colleague of mine who oversaw the communications that arrived, but from a numerical point of view, they were really of little significance.*
>
> Interviewee N_1

As *Figure 2* at the beginning of the chapter shows, local healthcare authorities were a pivotal step in the designed DCT procedure because they granted the connection between the users and the app signaling

features. Initially, healthcare authorities and GPs were the only actors that could unlock Immuni to users tested positive so they can send notification of risky encounters to the registered close contacts. Since these relevant actors did not properly interact with Immuni, the serious issues described in the previous paragraph emerged.

The relevant updates introduced in the DCT procedure towards the end of 2020 and the beginning of 2021, as picture in *Figure 1*, tried to solve these problems. A call center was introduced to provide the users an additional option for unlocking the signaling feature of Immuni. Then, the users could unlock the app on their own through specific codes they received once tested positive. However, it is quite easy to imagine how these yet significant updates, coming more than six months after the release of the technology, did not largely impact the users' opinions, the number of downloads, and ultimately the reputation of the app, already largely jeopardized by previous problems and issues.

Despite not relying on Immuni, the interviewed local healthcare authorities sought solutions in digital technologies to try to manage the enormous number of positive patients that emerged especially during the second wave. Considering these solutions seems relevant also for the broader analysis of the DCT strategy in Italy.

3.5.1 The alternative digital contact tracing strategies of local healthcare authorities

The leadership of the authority of the Northern Italian region interviewed for this research explained how they decided to try to digitize the standard manual tracing process. Initially, they used some basic tools, which soon proved equally unfeasible. Then, they looked for external support for developing a more complex strategy, which ultimately became widespread among most of the local authorities of the same region.

> *So, we had to somehow do something. It has been a process: we started from lists more or less in Word, then moved to Excel sheets, where we tried to collect all the necessary information, from Excel, when the numbers continued to increase, we switched to Access and then we said: "we can't do it anymore". […]*
>
> *Hence our idea of seeing if someone could help us set up a system that could allow us to manage contact tracing quickly and easily, above all the interface and management, the interface with all regional flows, both as regards swabs, then laboratory flows, etc.*
>
> *From here we contacted a software house that was already working with an application for the management of food safety, saying "listen, can you help us? Can you help us in some way?"… And using an application that they already had, but intended for the management of rare diseases, with slight modifications we have arrived, we have begun to set up what has become E-Covid, which is our contact tracing management system. Next to this - and it is a tool that was created basically on our needs […] - we have an application that allows us… when the positive person is reported, this person receives a text message in which there is a link, and the person is asked to enter this link and then report all his/her contacts. On the other hand, s/he receives a whole series of information regarding isolation,*

quarantine, procedures, the quarantine certificate can be downloaded automatically, then to be used, the end-of-surveillance test can be booked.

Interviewee N_1

Interviewee O, the professional from a healthcare authority in Central Italy, recalled a similar approach to support manual contact tracing which became highly challenging due to the high numbers of infected people. However, that intervention had some significant privacy issues, which made it not applicable also to other regional contexts due to the intervention of the Privacy Authority.

The person received a link via text message. So, let's say a different link for each user and there the person had the possibility to trace his contacts […]. In this case the legislator intervened, establishing some important elements (ed. limits), so it is an experience that could not be applied to the whole region, because there was… in short, the Privacy Authority set some limits and also it had anticipated that it would have defined sanctions.

Interviewee O

Similarly, privacy was an issue on which the Northern healthcare authority spent some time, as *Interviewee N_1* stated, "in order to avoid problems that might have occurred in some other ATS [ed. local healthcare authorities], where a similar system had been used".

Besides the just mentioned digital approaches to contact tracing, *Interviewee O* described other ways in which these kinds of technologies could have supported such an endeavor.

At a regional level I had asked the councilor to activate a tracing system through the fiscal code, that is, [for] anyone who went either to the barber shop or to the restaurant […]. I asked the councilor, he gave me his ok, then it was blocked for other reasons [...]. This would have helped, so digital tracing would have helped manual tracing. But let's say that in this case the Immuni app has always been politically stronger.

Interviewee O

Stressing also how much possible different digital alternatives have been largely under-utilized.

So, we have forgotten the potential of digital, we have forgotten the potential of information gathering [...] And so, perhaps, now I raise the bar a lot ... the Chinese system of forcing everyone to have an app… forcing everyone to have a mobile phone perhaps would have been the bloodiest and most invasive solution, but that would certainly have allowed to limit the damage in terms of GDP. Because in the end we are talking about that, we have had an excessive number of deaths, and economic and financial damage.

[…]

> *When it comes to tracing, [we need to] rethink and reformulate the idea of tracing. Because it is not only Immuni, but there is also other information as I told you before: the fiscal code when you go into a public business; the movement of the mobile phone…*
>
> Interviewee O

Among the two described digital contact tracing strategies that have been employed by the two authorities, and also among the possible uses of the digital pictured by *Interviewee O*, Immuni, or at least some of its main features, went almost unmentioned. It therefore emerges how digital technologies were perceived as a possible solution to the daily issues of managing extremely large numbers of infected people and related close contacts. However, in the words of the healthcare authorities' members, the features of Immuni did not seem to tackle these issues. As Interviewee N_1 put it, the number of notification that the authority received from the app were very few compared to the information coming from the positive swabs test. Conversely, the digital strategy of authorities that did not largely relied on the app arguably contributed to making the tracing procedure through Immuni even more complicated. A mix of these reasons ultimately contributed raising some of the issues discussed in the previous paragraphs.

4. Immuni's design, implementation, and use wrap up

This chapter has tried to reconstruct the process that brought the development of a technological solution for implementing a DCT strategy in Italy. It has been shown how the Italian institutional actors, mainly thanks to the work done by two groups of experts, selected the Immuni app among many proposed alternatives. From the interviews with some of those experts that participated in this process, and from the analysis of official documents, it emerged that privacy and data protection were two core elements that guided the selection process.

The implementation of the selected solution run quite smoothly since most of the work was done, as it has been described in the previous chapter, by Apple and Google who developed a technical framework, later employed by many EU countries.

With respect to the use phase that followed the development of the Italian DCT solution, the analysis mainly pivoted around the reviews posted by users on the Google Play Store, but it also considered the interviews with the relevant actors involved in the early processes. From the reviews, it emerges that privacy and data protection do not seem to be as pivotal for Immuni users as for those who chose it as the official solution. Users seem more focused on technological issues of the app in use: whether it affects the battery of the phone or not, or sharing what kind of errors and bugs the app presents, etc. Through all the main considered parameters, the audience emerged as highly split. When considering the ratings of all the scraped reviews, 42,7% of them had 1-star ratings, while 35,2% had 5-star ones. Similarly, 24,5% of most recurrent trigrams fell in the negative evaluation category and 18,4% in the positive one. Finally, the positive and negative evaluation theme had almost the same weight in the qualitative analysis of the top100 liked reviews. From

the qualitative analysis it also emerged that, in users' eyes, the main pros of Immuni were related to data protection and technological implementation, both from the hardware point of view, with the impact on the battery life of the smartphone for instance, and from the software point of view, regarding the graphical interface. Conversely, when posting negative evaluations, users of course mainly mentioned technical elements, but also stressed more organizational issues, such as the role of local healthcare authorities in managing the tracing procedure. Several users reported the struggle to get in touch with healthcare professionals to try to make the app work properly. This issue has been also stressed by several relevant actors interviewed for this research. The scenario emerges to be the following: local healthcare authorities were considered a pivotal actor in the designed DCT procedure through Immuni, but in the day-to-day tracing activities they did not rely on it, contributing to marginalizing the DCT strategy with respect to the other NPIs implemented to fight the pandemic. As several interviewees put it, the main struggles of DCT through Immuni, should not be related to its digital elements, namely the app itself. Of course, the app had some bugs and technical errors, but its main issues were probably largely related to non-technical elements, such as the integration of the app in the digital tracing strategy of the local healthcare authorities, and proper and effective communication campaigns.

It must be stated, and it should be quite visible from the analysis presented so far, that the design and implementation of the DCT strategy through Immuni in Italy largely – if not mainly – focused on its digital elements. The fact the Ministry of Innovation oversaw the whole project tells a lot about the set of competencies, priorities, and values that were deployed in it. When this set of elements is considered, it is not that surprising that this policy/technology solution faced significant issues with respect to non-technical elements. It included as a pivotal actor in its deployment an actor that did not participate in the development process and whose needs and values did not match those of the designers. As already stated in the previous paragraph, towards the end of 2020 and at the beginning of 2021, relevant updates to the organizational features of Immuni were made. Referring to the local healthcare authorities was no more the one and only way to unlock relevant Immuni features, namely updating a positive status and sending signals to close encounters. However, as most of the problems emerged with the second wave in October-November 2021, most of the Italian users were already discouraged by the app's weaknesses, and the number of downloads never really took off after that period. These reasons contributed to making Immuni a marginal NPI in the fight against COVID-19 in Italy.

4.1 Succinctly picturing the Italian DCT strategy

Based on the analysis presented in this chapter and the one of the previous one as well, a series of relevant actors can be identified in the development of the Italian tracing technology. As *Figure 12* shows, the whole strategy lays on the technical affordances of a non-human actant, that is Bluetooth. The role of this technology has been attentively tackled in the previous chapter, as well as the control that the two tech firms

Apple and Google have on it because of their mobile infrastructure. The previous chapter also described how the role of Apple and Google largely influenced the whole process that brought to each country's DCT strategy deployment. Moreover, this chapter offered the chance to show how the relationship between the two tech firms and the national public institutions developed with respect to the implementation of the DCT strategy through a CTA. Within the broad domain of national public institutions, also falls the local healthcare authorities, whose role in the issue of interest has been attentively investigated. The relationship of this last actor with an additional pivotal one, namely the users, has been tackled as well. Users represent the last step of this bundle of relationships between actors and actants that brought to the rollout of the Immuni app, the main technological artifact through which a DCT strategy has been carried out in Italy.

Two additional relevant actors have been considered in the previous chapter but are not pictured in the following scheme. That is because, as the analysis of Immuni design, implementation and use showed, the impact that the scholars developing the different protocols and the European Union had on the actual deployment of the whole strategy is not as crucial as the impact of the other elements just mentioned.

Figure 11 – Different actors and actant that contributed to the deployment of the DCT strategy

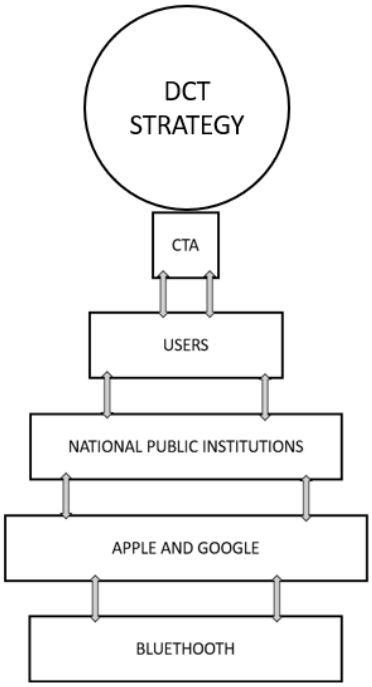
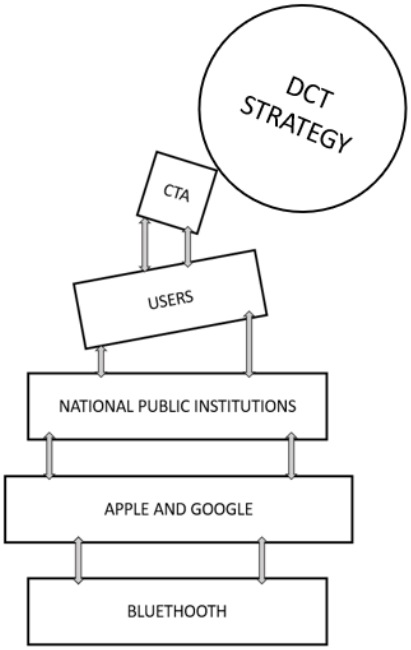


Figure 11 graphically shows a quite straightforward model that, with actors building on each other contribution to the task of interest and developing relationships with one another, pictures the accomplishment of a DCT strategy through stability. However, as the materials previously analyzed showed, the relationship between the involved actors and actants was far to be smooth and stable, which ultimately jeopardized the success of the DCT strategy itself. That is why *Figure 12* seems a more proper way to picture how the deployment of the DCT strategy developed. The previous pages showed how the relationship

between users and public authorities, especially local healthcare ones, was a messy one. Furthermore, the relationship between users and the CTA itself was a problematic one. These described issues contributed to creating "shakes" in the equilibrium pictured by the previous model and ultimately made the DCT strategy "fall".

Figure 12 – The "fall" of the Italian DCT strategy due to problematic relationships between actors and actants



Chapter 6 – StopCovid, TousAntiCovid, and digital contact tracing in France

After having considered the development of the DCT strategy in Italy, which was mainly realized through the implementation of the app Immuni, it is time to focus on France and its strategy. It has been already stressed how France is a relevant case to study the development of DCT in Europe. First of all, it is the main country that followed a centralized approach in developing its own CTA, refusing to rely on the Apple and Google's ENF. Then, France rebooted its own app because political decision makers were not satisfied with the first version. StopCovid and TousAntiCivid, the two versions of the French app offer the chance to focus on some specific elements of these technologies.

As described in chapter 3, the empirical materials available for the French case are fewer than the ones gathered for Italy. The reasons for this shortage have been already explored, but it has also been already mentioned how the available empirical materials offer the opportunity to develop a proper analysis of this case anyway. Therefore, this chapter would try to replicate as much as possible the structure of the previous one. For sure, the logic of presenting the materials has been kept equal, relying on two already mentioned principles. First of all, the case study will be presented following as much as possible the chronological order of the development of tracing technologies in France. Then, a large share of attention will be dedicated to the role of relevant actors in this process. Before moving to the actual case analysis, it is useful to remind that the analyzed documents cited in this chapter were timely reported in *Table 3* in chapter 3, where the research design was presented. In that table, each document is properly referenced. So, in this chapter, for the sake of smooth reading, the long list of references will not be reported again. Interviewees' descriptions and categorizations are reported in the same chapter as well, in *Table 7*. Still, a brief description of them will be reported in the following paragraphs, always to ease the reading and understanding of this chapter.

1. The design of DCT in France

1.1 The National Government's plan

The French Government's interest in DCT brought them to partner with Inria, the National Institute for Research in Digital Science and Technology, between March and April 2020. As *Figure 1* shows, Inria started reflecting on possible contributions in the fight against COVID-19 in the final days of March, and on April 7th the French Government asked the Institute to create and lead a task force that would have developed the CTA StopCovid (Inria, 11 May 2020).

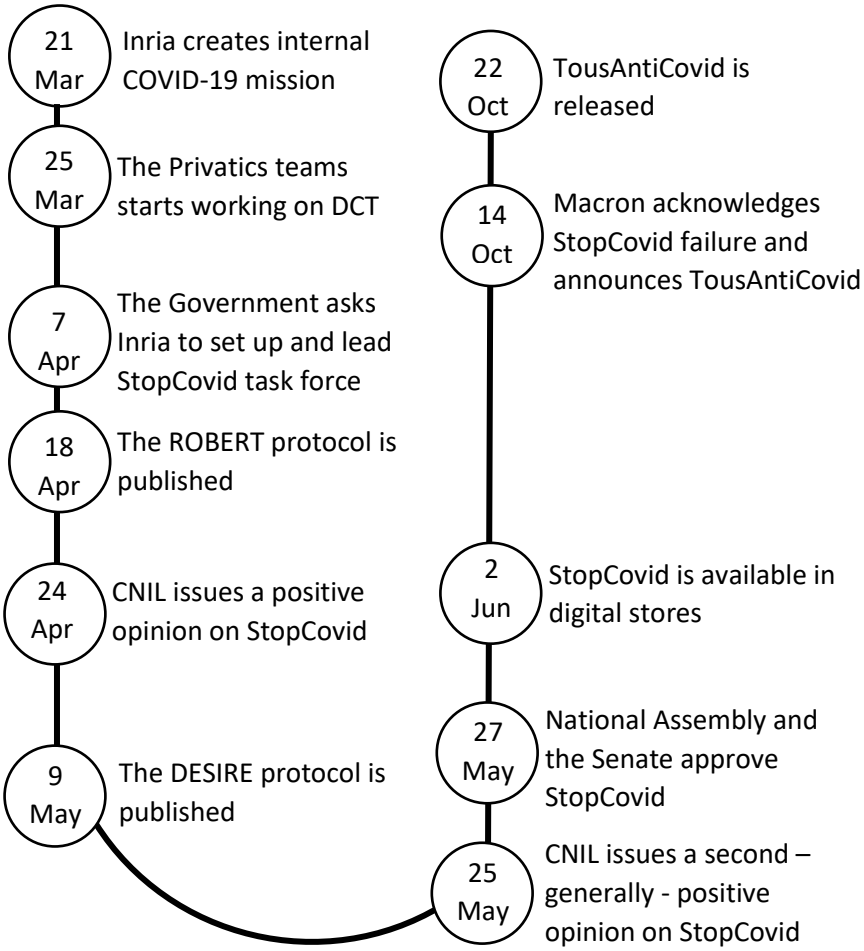
The initial approach to the development of DCT seems quite smooth and straightforward: the Government asked arguably the most relevant research institute for digital technology in the country to guide the development process of the new digital technology. Exactly on this unobstructed process of DCT initial

development, one of the interviewees expressed some concerns. As a computer scientist, *Interviewee Q* claims that there was no debate fostered by political decision-makers on whether the CTA would be useful at all, and what kind of risks and threats may emerge from its implementation.

> *From the very beginning the politicians were announcing this app, but without any concern on the risk-benefit balance. I mean, we were very astonished that there was no discussion about whether this could be useful or not. (…)*
> *What we wanted, I think that the reaction of the academic community was that, at least from the cryptographers' point of view, there are definitely risks into doing this and we should have a discussion about what those risks are and whether it's worth it, and what are the benefits, and just have a good, enlightened, debate about that, but not definitely jump into this solution and not think about the risks.*
>
> Interviewee Q

The same lack of public debate on the early phases of the creation of the whole DCT strategy in France was also mentioned by *Interviewee R*, another computer science scholar.

Figure 1 - Timeline of French DCT strategy development



After the initial partnership between the French Government and Inria, the development of the DCT strategy in France continued with the development of the ROBERT protocol (the centralized protocol already described in chapter 4), and the involvement of the French Data Protection Agency (CNIL), which will be later considered, until the release of the StopCovid app on June 2nd, 2020. It must be anticipated that the StopCovid app did not last long in the French DCT strategy. As *Figure 1* shows, four months after the release date, the app was replaced by a new one, called TousAntiCovid. The following pages will analyze this element as well, but first it should be considered the role that Inria played in the whole development process.

1.2 The role of Inria

As a leader of the DCT project, Inria coordinated the activities of several French public and private actors who contributed to the early development of StopCovid. The project involved, besides other players, the French National Cybersecurity Agency, the National Institute of Health and Medical Research, the Healthcare Agency, Capgemini, Dassault Systèmes, Lunabee, Orange, and Withings (Inria, 11 May 2020).

By considering Inria's official statements, the core elements and values that guided the design of the French app emerge. In one of the earliest public statements on the project, Inria's CEO, Bruno Sportisse, stressed that the CTA under development was not a tracking tool, since it just relied on Bluetooth, and that "it has been designed in such a way that NOBODY, not even the government, has access to the list of people diagnosed as positive or to the list of social interactions between people" (Inria, 18 April, 2020). Furthermore, Sportisse reflected also on the challenges and limitations of CTAs. First of all, he focused on the technological constraints of Bluetooth, pointing out that it is a technology developed for communication purposes and not for measuring. Then, he also stressed that, at the time, it was not even exactly clear how the virus would spread between individuals, whether via "aerosol transmission or transmission via droplets". Furthermore, Sportisse mentioned the challenges emerging with respect to the information-sharing protocols, and the well-known debate between the centralized and decentralized approach (Inria, 18 April, 2020). Since the early phase of DCT development in France, issues with information-sharing protocols and interoperability between different countries' solutions emerged, and some misalignments between them could already be spotted. As Inria explains, representatives from different countries were not on the same page with respect to risks related to DCT. For instance, supporters of the decentralized approach stressed the fact that CTAs users needed to be protected mainly from government's surveillance, which could happen more easily when using a centralized approach to DCT. Furthermore, countries did not agree on the role of Apple and Google with respect to these technological solutions:

> Another challenge is interoperability. This is the reason for France’s involvement, through Inria, in the PEPP-PT initiative, which we discussed earlier, alongside teams from Germany, Italy and other countries. We might not always agree on the decisions taken or on the hypotheses proposed (e.g. who is most likely to carry out an attack? A democratic country or a hacker, perhaps not even a particularly

> smart one, and certainly not always an ethical one). We might not all place the same emphasis on the issues of digital and technological sovereignty. Regardless, we work together on a scientific and technological playing field, to build solutions which respect the values that we share and which are interoperable (the applications deployed will have shared components but will be national given the importance of forming part of a national healthcare system). During these unprecedented times for our nation, France can turn to its research and innovation ecosystem to successfully carry out projects capable of simultaneously meeting the required levels of effectiveness for public health policies, respecting individual freedoms and maintaining or even reinforcing our digital and technological sovereignty (Inria, 18 April, 2020).

From the materials published with the technical documentation of StopCovid, additional principles that guided the development of the tracing solution emerge. The team worked on developing a CTA that could be included in the broader strategy of the fight against the pandemic, being strictly compliant with national and EU data protection laws and guidelines. Transparency was another core element in the development of the technology, reached through the dissemination of an open-source code. Moreover, the process was designed to be a temporary intervention, subjected to the development of the coronavirus pandemic. Finally, the Inria developers stressed the "respect for the principles of digital sovereignty of the public health system: control of health choices by French and European society, protection and structuring of health data assets to guide the response to the epidemic and accelerate medical research" (TousAntiCovid read me).

The leadership of Inria, and especially of one of its groups named Privactics, was not perceived as positive by some of those involved in the computer science field in France. As *Interviewee R* puts it:

> *Most of the community was unhappy because the team that was chosen was not the team that was specialized for designing protocols. I mean, they are very good in... most of the time what they do is they analyzed protocols and try to break them and find frauds in them. Here they were asked to do the exact oppositive, they were asked to build a new one. It was really strange.*
>
> Interviewee R

Despite it goes against the chronological order of the development of the French DCT strategies, the next paragraph would make a temporal jump to October 2020, and consider the TousAntiCovid app, which replaced the StopCovid one. It is a jump that is anyway justified by the fact that the rebranded app significantly impacted some of the initially designed features for StopCovid.

1.3 Restyling the official contact tracing app: TousAntiCovid

On October 14th, French President Emmanuel Macron announced that a new CTA was ready to be released since StopCovid "did not work", also because, in four months, just 2.6 million French downloaded the app. The new app, called TousAntiCovid, would add new features to the contact tracing one, making it a sort of hub for COVID-related news and tasks (Reynaud, 2020).

Vincent Roca, director of the Privatics group at Inria, in his written answers gathered for this research, explains the process that led to the new app and its main features.

> *StopCovid/ROBERT was working fine, technically speaking, yet the app design principle (nothing seems to happen, the user interface is kept voluntarily minimal), the lobbying against the FR solution, and undoubtedly a general distrust against the FR president (we have faced two major protest movements in the previous two years) made it a failure.*
> *The design changed totally with TousAntiCovid that is now much more than a contact tracing tool: it's a hub, with information about the pandemic (10 key figures approx.), advice (how to behave in case…), the possibility to generate digital attestations when we need to leave home during the lockdown (very convenient), soon a wallet to store vaccine certificate or similar, etc. This complete change made it a great success, as an app, and it is now at the center of the FR strategy.*
> *Contact tracing works exactly the same in SC and TAC (ROBERT), of course with a few improvements (specially to better mitigate Apple technical limits when doing BLE processing in the background).*
>
> Inria

Interviewee Q gave his perspective on the issue, as it was perceived from outside the developing team.

> *I mean, the number of downloads was extremely low, and it was not a recommended by the politicians, the health Ministry did not say anything about this app, you know they just said: "wear masks and wash your hands etcetera". So, it was not... there was no communication about the app because, when they launched it, something had gone really wrong. They launched it too fast, with a bad debate, nobody wanted this, and they did it anyway. So, a few months later, they decided probably under... with some advice from the communicators that they should just, you know, rebrand it. So, you change the name, and you add some features, and you say: "now this is completely new, and we make a lot of communication".*
>
> Interviewee Q

So, since October 2020, France has been using a CTA that "it's a hub" for several features tackling different COVID-related issues. The initial DCT feature is still present but is not the only one anymore. The analysis of users' reviews towards the end of this chapter would talk more about whether this update was appreciated or not by the French population who decided to use the app.

After having considered the two main actors, namely the French National Government and Inria, that contributed to the design of the French CTA, focusing on the principles and values that guided the technical choices, it is now time to consider the different steps that took to the technology's implementation.

2. The implementation of the French CTA

The implementation of the French CTA did not run as smoothly as the previously described Immuni one. The main difference between the two is that the French app did not rely on the Apple and Google protocol, the

Exposure Notification Framework (ENF). As described in chapter 4, StopCovid was designed based on the centralized protocol ROBERT, which was developed by Inria as well.
Vincent Roca explains why they decided to follow a centralized strategy.

> *I can explain why we decided to switch to a centralized approach though. First natural reaction when facing the problem is to think about a decentralized scheme. This is what we explored first. However, in the very first days of April, it became clear that the major downside is the need to share all the pseudonyms of all COVID+ persons in order to let each smartphone assess risks (are those pseudonyms part of those I've crossed during the past few days?). In other words, it means sharing a database of health data (COVID+ status) that is only pseudonymized (pseudonyms are shared through the daily TEK keys that enable to compute them). This is in total contradiction with the basic GDPR rules regarding sensitive data protection.*
>
> *[…] We decided to explore another path, for France and Germany (more generally democratic countries) that benefit from trustworthy institutions and Data protection agency. This is not a universal model (we wouldn't recommend it in an authoritative country) but it's more protective in case of France as it hides the health status of COVID+ users, and with a good design, it does not raise any social graph issue unlike what has been said. This is where our assumptions on trustworthy institutions and Data protection agency are important.*
>
> Inria

As already reported in chapter 4, he also addressed the issue of Apple and Google having another approach and trying to delegitimize any other tracing strategy. Vincent Roca mentioned a video of a conversation between Shoshana Zuboff, the mother of the "surveillance capitalism" concept, and Margrethe Vestager, Executive Vice-President of the EU. In the discussion, Zuboff supports the same idea, stressing how Apple and Google's behavior in DCT development is oriented towards the delegitimization of Public Authorities' role, especially with respect to the protection of users' personal data (IDA, 2020).

> *Google / Apple/ EPFL and others could have promoted their solution in a fair manner, comparing the respective merits of approaches. But they decided to discredit all the other solutions, through scientific, political, and technological lobbying. That's something totally different. Of course, doing so, they never explained that GAEN comes with a major issue: it does not protect the health status of those who declare themselves through the app. This issue has never been mentioned at that time*.
>
> Inria

From his outsider perspective of computer science scholars, *Interviewee R* commented on the involvement of the two tech firms in the development of DCT strategies, stressing on one hand the pros of having an easy-to-implemented solution, but also the cons of losing control of the project.

> *From the one side its nice because they [ed. Apple and Google] could have access to extra features, the firmware, and they can develop better apps that are better in communication. So, here it was really helpful in this solution… But the main problem is that we don't really trust Apple and Google to be nice*

with this data, and especially healthcare data, and we don't want to send them to the US, or to company that are linked to the US at least. That was really scary to see them enter the field and say: "we are going to provide you with the solution, but we keep control of the core of it".
So, it was really a mix of very good things and very bad things. So, I've discussed with people that worked on the GAEN directly, and they were nice people that were trained to do nice things, it was good crypto in the protocol, but you never know what happens behind and you never know if someone in the management, or whatever, is going to get some pressure to change something to change their mechanism and make them able to enter data. That was really scary.

Interviewee R

The issues of control and the chance of having Apple and Google involved in the development of the national tracing strategy were largely discussed also in the French Senate session on May 27th, 2020, another key step in the process of StopCovid implementation. In that session, the Members of Parliament (MPs) were asked to vote on the implementation of the DCT strategy with the StopCovid app.

2.1 The French Senate debates on the DCT strategy

The analysis of the transcription of the MPs debate during the Senate session shows that among the most relevant discussed topics, with respect to the DCT strategy, there was the issue of centralization and decentralization of tracing protocols. Some MPs argued that there are both pros and cons with either solution. However, an MP, sharing the Government's stance on the issue, gives a quite clear framing of the issue, which suggests the perspective from where most of the other relevant matters were tackled during that session.

I therefore approve the Government's [perspective] regarding the centralization of the application, without going into too much detail, you actually have the choice between a centralized server, under the responsibility of the Directorate General for Health, and, as regards a decentralized solution, a list of positive contacts on a Google server.

MP Philippe Adnot

The issue of interoperability, which already emerged among the principles that were considered during the design phase, was largely discussed as well. Since the French solution relied on a centralized approach, it could not communicate with most of the other EU apps, adopting a centralized protocol. The Secretary of State, in charge of digital projects, addressed this issue.

It is true that European paths have diverged on the issue [ed. centralized vs decentralized] and that, for political, and not technical, reasons, Germany preferred to retain the solution developed by Apple and Google rather than the French solution.
I'm not going to lie to you: the possibility of decentralized and centralized solutions being interoperable is very limited. It will be very complicated to have an interoperable solution at European level, and I regret that.

[…] It is unfortunate for Europe's digital sovereignty that such a choice was made by a number of our partners.

I don't think the story is completely written. Yesterday, I signed with my German, Spanish, Italian and Portuguese colleagues a forum on European digital sovereignty which was particularly aggressive, in any case pugnacious, with regard to Apple and Google.

Secretary of State Cedric O

As O's statement shows, discourses around interoperability were strictly connected to the involvement of Apple and Google in the definition of the decentralized protocol. Several MPs addressed the issue of big tech's involvement in DCT, approving the fact that France chose to develop its own tracing protocol.

Above all, StopCovid raises an extremely important question: I am delighted that this application has been developed in a public framework, because we must not let the Gafam [ed. abbreviation for: Google, Apple, Facebook, Amazon, and Microsoft] establish a monopoly on our most precious asset: social ties, social life. But Apple and Google, to name these companies, have already shown themselves ready to do so; and in some countries they already do.

There is somewhere a form of naivety, which ultimately leads us to give up, to let our guard down in the face of digital giants who would be very happy to see that a State refrains from acting in this area.

MP Julien Bargeton

Furthermore, strictly related to the role of two US commercial actors, MPs tackled the issue of digital sovereignty on several occasions, stressing different sides of it and expressing significant concerns.

This is why, in my eyes, the strongest reason to give this application a chance is that of digital sovereignty. Since the start of the crisis, we have been talking a lot about sovereignty, which is available in all areas. My dear colleagues, if you do not want to be traced or geolocated, do not use your smartphone. Objectively, as the CNIL reminded us, the application that we are offered is much more protective!

MP Bruno Retailleau

The Government has made the effort, despite pressure, to develop a French solution by refusing to increase France's dependence on Gafam. We hope that these are the first steps towards digital sovereignty, so essential to us.

MP Emmanuel Capus

I will be rather satisfied to lend my support to this project, which allows us to return on the notion of digital sovereignty, highlighted by the Senate last year, thanks to its commission of inquiry on the subject.

MP Sophie Primas

The general relevance of these issues clearly emerges from the words of Secretary of State, Cedric O, who in his opening statement declared.

> *To date, twenty-two countries have chosen to develop a contact protection solution based on the interface developed by Apple and Google. Many of these twenty-two countries are in Europe, but neither France nor the UK are on the list. Is it the result of chance? They are, at the same time, the only two European states with their own nuclear deterrent tool, which is ultimately the pinnacle of national sovereignty.*
>
> *There is nothing dogmatic about this refusal. It is not opposed, per se, because it is about Apple and Google; but because a large company, however efficient and innovative it may be, does not have to constrain the health policy choices of a sovereign nation; because, to guarantee the security of the data of the French and the health efficiency of the system, France has chosen independence.*
>
> Secretary of State Cedric O

During the debate, MPs also stressed the importance of defending individual freedom of choice on whether to use or not the app. Furthermore, the centrality of data protection was also tackled. The members of the Government who participated in the session stressed several times how the CNIL issued positive evaluations with respect to the management of personal data carried out by StopCovid.
Some MPs, very few actually, expressed opposing perspectives, especially concerning surveillance threats, damages to personal freedom, and risks of technology misuse by the Government.
Within this broad set of discussed issues, however, the most covered ones were those related to digital sovereignty, namely the chance to have an independent tracing solution from foreign tech corporations' constraints and guidelines.

2.2 Towards the app roll-out

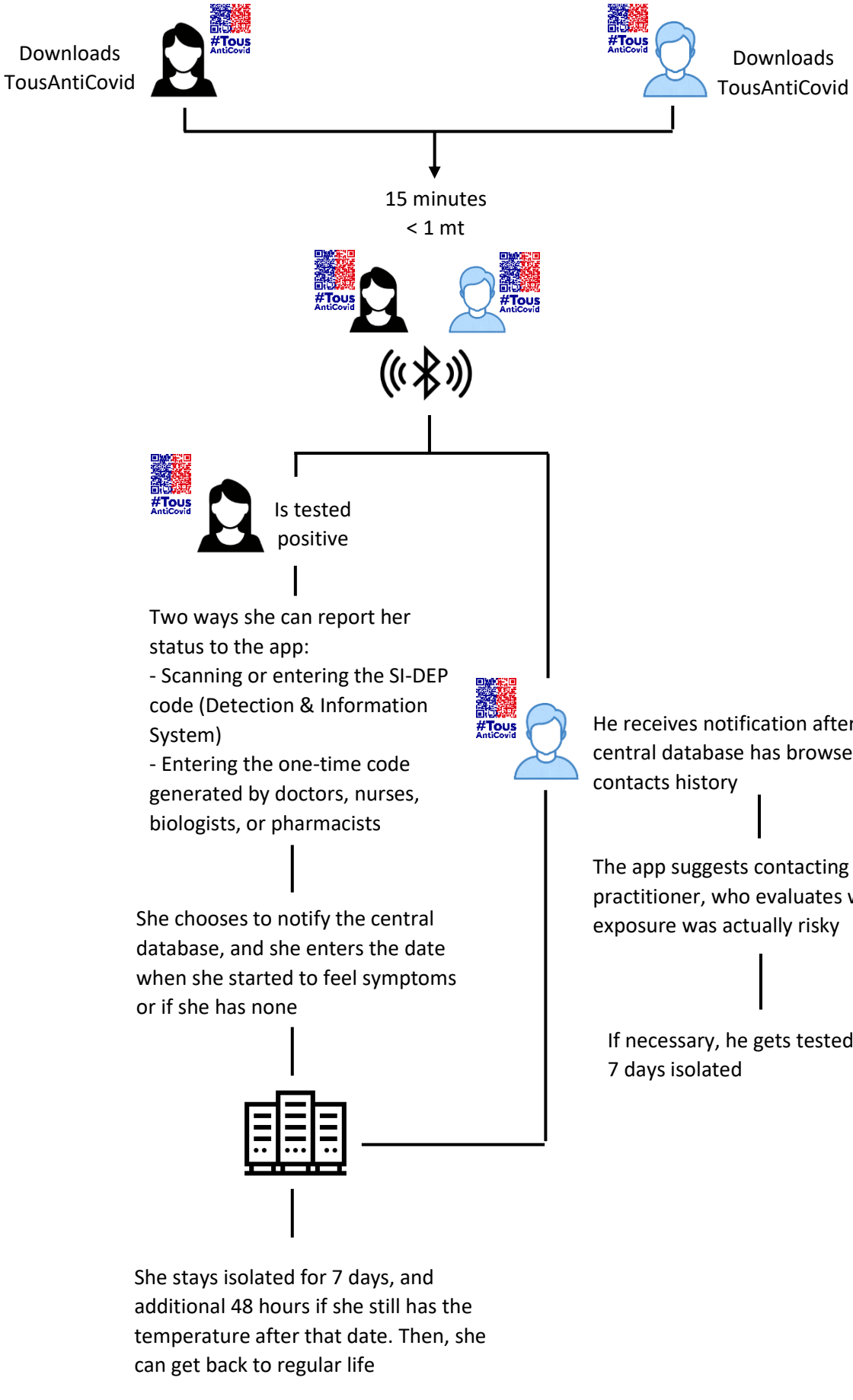
Figure 1 shows that in the development path towards the app launch on digital stores, the DESIRE protocol was developed. There is no need to go into technical details of this solutions developed by Inria, also because its impact was very limited. The goal of DESIRE was trying to overcome the interoperability problem between ROBERT and the ENF, bringing a better integration of EU tracing strategies. However, this solution never really spread outside France, and it was not implemented.

Another relevant step in the development of StopCovid, as already mentioned in the previous section, was the approval issued by the CNIL. The French Data Protection Authority recognized an unprecedented involvement of issues related to users' privacy in the development of a tracing strategy. However, after having analyzed the proposed solution, the CNIL stated "that the presence of personal data does not, in principle, prevent the implementation of the system. However, it imposes the provision of suitable safeguards which are all the stronger as the technologies are intrusive, safeguards under which the attenuation of the possibilities of reidentification constitutes an essential measure" (CNIL, 2020, p. 4). The CNIL also stressed the importance of the freedom of choice in the use of the app and the need to monitor the app's effectiveness throughout the months.

Finally, on June 2nd, 2020, the StopCovid app was released. Four months later, as previously described, it was transformed in TousAntiCovid. The tracing procedure largely remained unchanged, and it is the one pictured in *Figure 2*.

Even if the graphical representation reminds the Immuni's procedure pictured in the previous chapter, some relevant differences arise. First of all, the local healthcare authority is not the only actors that can "unlock" the app and enable the user to start the signaling procedure when s/he is tested positive. Then, the central database browses the list of risky contacts. That is the main feature of the centralized approach, as described in chapter 4. Furthermore, it could be interesting to note that the designed tracing procedure of the Italian and French app is slightly different. The Italian app classifies as a risky encounter a contact between two people spending more than 15 minutes at less than 2 meters distance, while the French ones it classifies as such a contact at less than 1 meter distance. Moreover, it should be mentioned, even if it is not exactly part of the tracing procedure, that the quarantine period is different in the two tracing strategies analyzed so far.

Figure 2 - How the digital tracing procedure works with TousAntiCovid



After the implementation of the app, the using phase starts. The upcoming section specifically focuses on it through the eyes of the users who reviewed the app.

3. The official French contact tracing app(s) in use

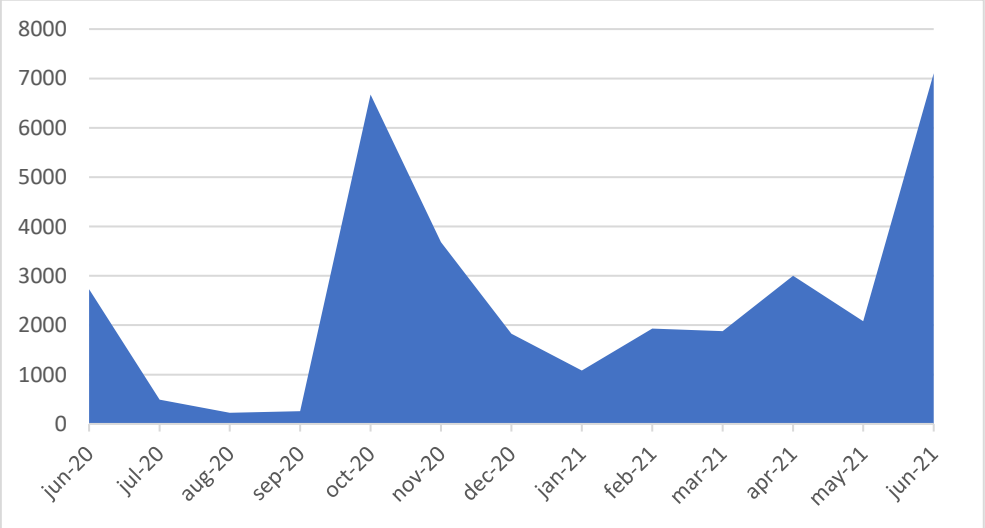
The value that the analysis of users' reviews can bring to the understanding of the whole development process should be now quite clear. As happened for the analysis of Immuni, the reviews of the French CTAs posted online between June 2020 and June 2021 have been scraped and analyzed. It is important to state that, for both the StopCovid app and the later version TousAntiCovid, the digital stores' page did not change. Therefore, when scraping the reviews from the Google Play Store, those posted from June 2020 to October 2020 are referred to StopCovid, while those posted after that date cover the TousAntiCovid app. The general database of the French reviews that have been used for this analysis contains 35094 reviews.

As for the previous chapter, the following paragraphs will initially present some descriptive statistics on the large corpus of scraped reviews. Then, the most recurrent elements of the contents posted online by users will be considered, thanks to the extraction of n-grams performed through Python. Finally, a deeper focus on a selection of the 100 most liked reviews will offer the chance to identify the main concerns and opinions expressed by the users.

3.1 A descriptive snapshot of French user's reviews

One of the first elements that could be useful to consider when looking at the data from a descriptive point of view is related to the spread of users' reviews across the considered timeframe. As *Figure 3* shows, two peaks are clearly visible within the considered period. The first one is registered in October 2020, and the second one is registered in June 2021, and both largely surpassed the number of reviews posted right after the launch.

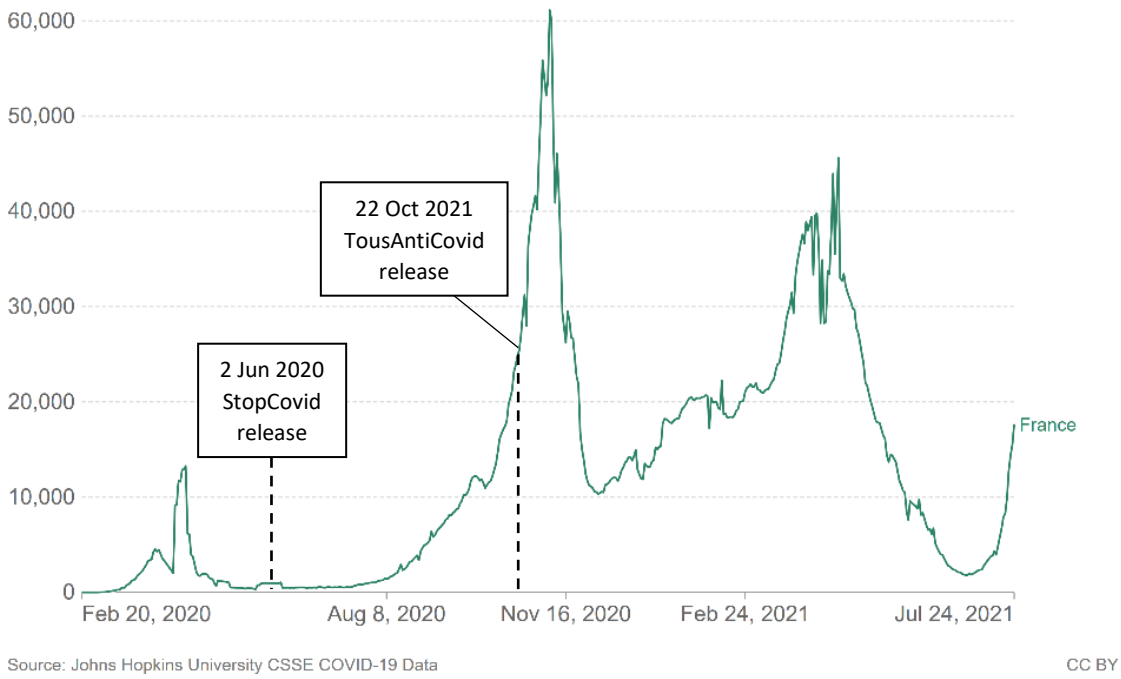
Figure 3 - Number of French reviews by month



Unfortunately, unlike the Italian case of Immuni, official publicly available statistics on the number of downloads are not provided. It is reasonable to hypothesize that the trend of downloads replicates the one pictured in *Figure 3*.

Like the previous chapter, *Figure 4* pictures the development of the number of contagions throughout the considered period.

Figure 4 - Number of positive people in France throughout the months



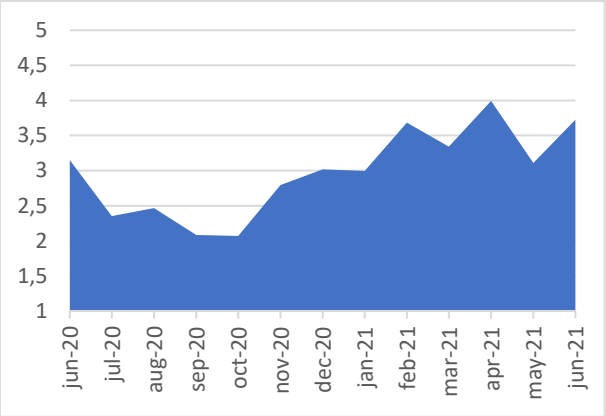
Source: Our World in Data https://ourworldindata.org/coronavirus/country/france, last accessed on 7/10/2022

By considering these two figures jointly, the first peak in the number of reviews around October 2020 could be explained by the increased number of contagions in the country, while the one of June 2021 does not seem to find a similar pattern in that statistic. The increased number of COVID patients is not the only, and arguably not even the main, reason why in October 2020 an increased number of reviews was registered. As *Figure 1* showed at the beginning of the chapter, around the same period the StopCovid app was substituted by the TousAntiCovid one, which carried with itself a larger media and public attention, which arguably impacted the number of downloads, and therefore reviews.

With respect to the peak of reviews of June 2021, a reasonable explanation could be found in the introduction, around the same period, of the COVID-19 vaccination certificate in France (Ministry of Finance, 2022). This new certification became mandatory to attend specific social activities, and one of the easiest ways to access it was through the TousAntiCovid app.

Besides these metrics, another descriptive statistic could offer additional information. When considering the average ratings that users gave to the StopCovid/TousAntiCovid app, as pictured in *Figure 5*, it emerges that the ratings increased after October 2020, when the switch between the two apps happened.

Figure 5 - Average ratings of the French app through months



Looking more closely at how this average rating result is obtained, *Figure 6* shows how most of the reviews were rated with the minimum (1) or maximum (5) score. On the other hand, *Figure 7* shows that the number of 1-star reviews was higher in October 2020, while the 5-star reviews grew towards the end of the considered timeframe.

Figure 6 - Share of French reviews with different ratings

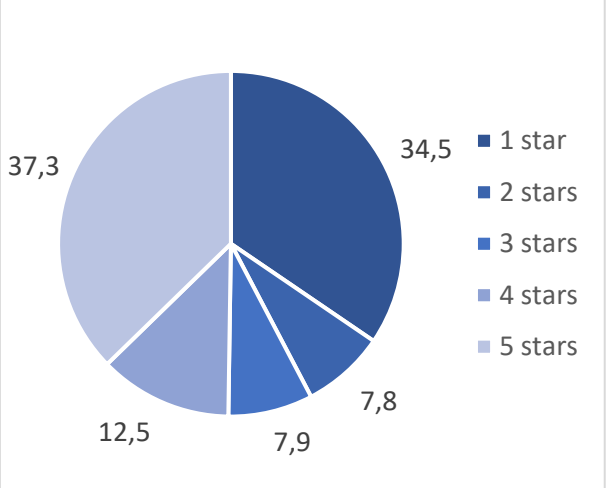
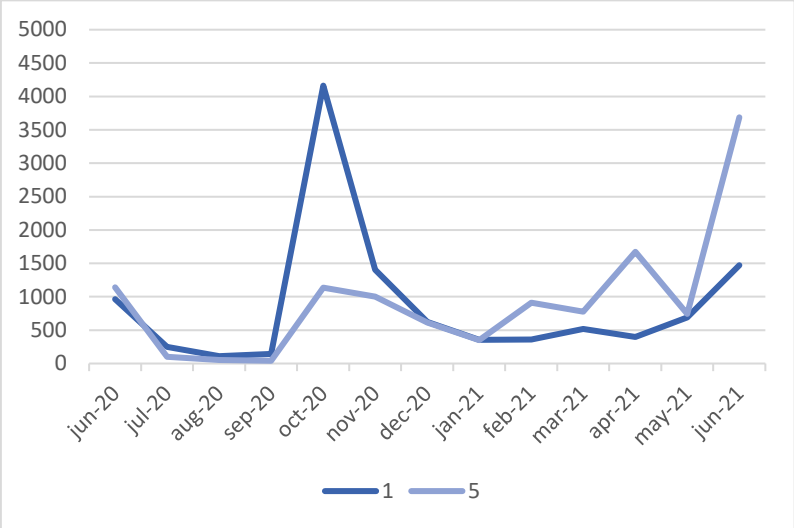


Figure 7 - Number of French reviews with 1-star or 5-star ratings throughout the months



3.1.1 Interpreting the data

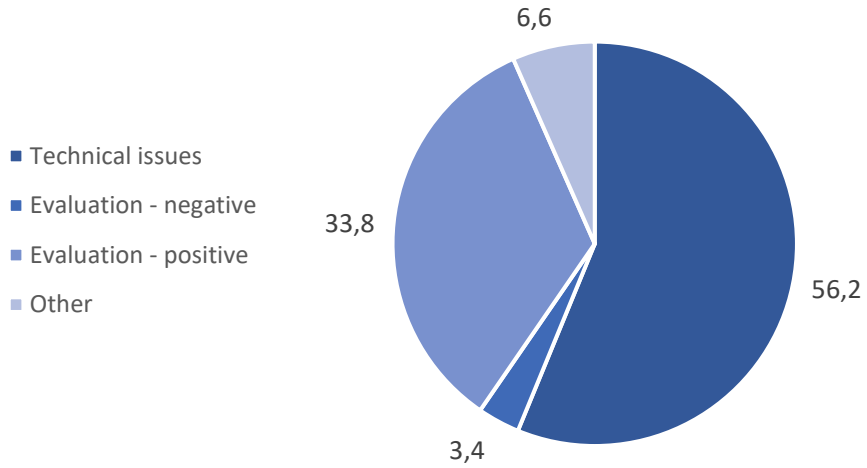
Through the analysis of descriptive statistics, it emerges that two key moments in the considered timeframe received a large share of attention from French users. Quite surprisingly, one of these moments is not the release of the app in June 2020. However, another "launch" received the largest share of attention from users reviewing the app, namely when StopCovid was replaced by TousAntiCovid. Another key "high-attention moment" was when the vaccination certificate was introduced in the app. These two key dates also replicate in trends of reviews ratings: most 1-star reviews were published at the TousAntiCovid's launch, while most of the 5-star ones were posted when the new function was added in June 2021. In general, the share of reviews with 1 or 5 stars are almost equally distributed, and they represent the largest part of reviews, suggesting that the audience was quite polarized when reviewing this app.

3.2 Zooming in: most recurrent topics in French reviews

The step further to better understand what French users think about their app is analyzing the most recurrent trigrams. A large number of trigrams and bigrams emerge from the basic natural-language processing analysis. The top20 most recurrent bigrams have been selected and are available in the *Appendix*, as well as the top30 bigrams. As for the Italian case, the top20 trigrams have been manually classified into categories. For this case, just four out of the previous five were identified among the trigrams: "Technical aspects", "Evaluation – negative", "Evaluation – positive", and "Other". *Figure 8* pictures the share of each category with respect to the group of top20 most recurring trigrams and their average users' ratings. Within the "Technical aspects" category fell trigrams related to the CTA updates, QR scanning, and the Internet or Bluetooth connection. The positive evaluation category contains trigrams on the app working properly; while the negative one contains a trigram related to the fact that the app was perceived as useless. The "Other" category groups a trigram reporting the name of the app and another one ("*this*, *application*,

very") which cannot be included in any of the other three ones, also because its true meaning can be hardly interpreted.

Figure 8 - Most recurrent trigrams categories in Italian reviews and related ratings

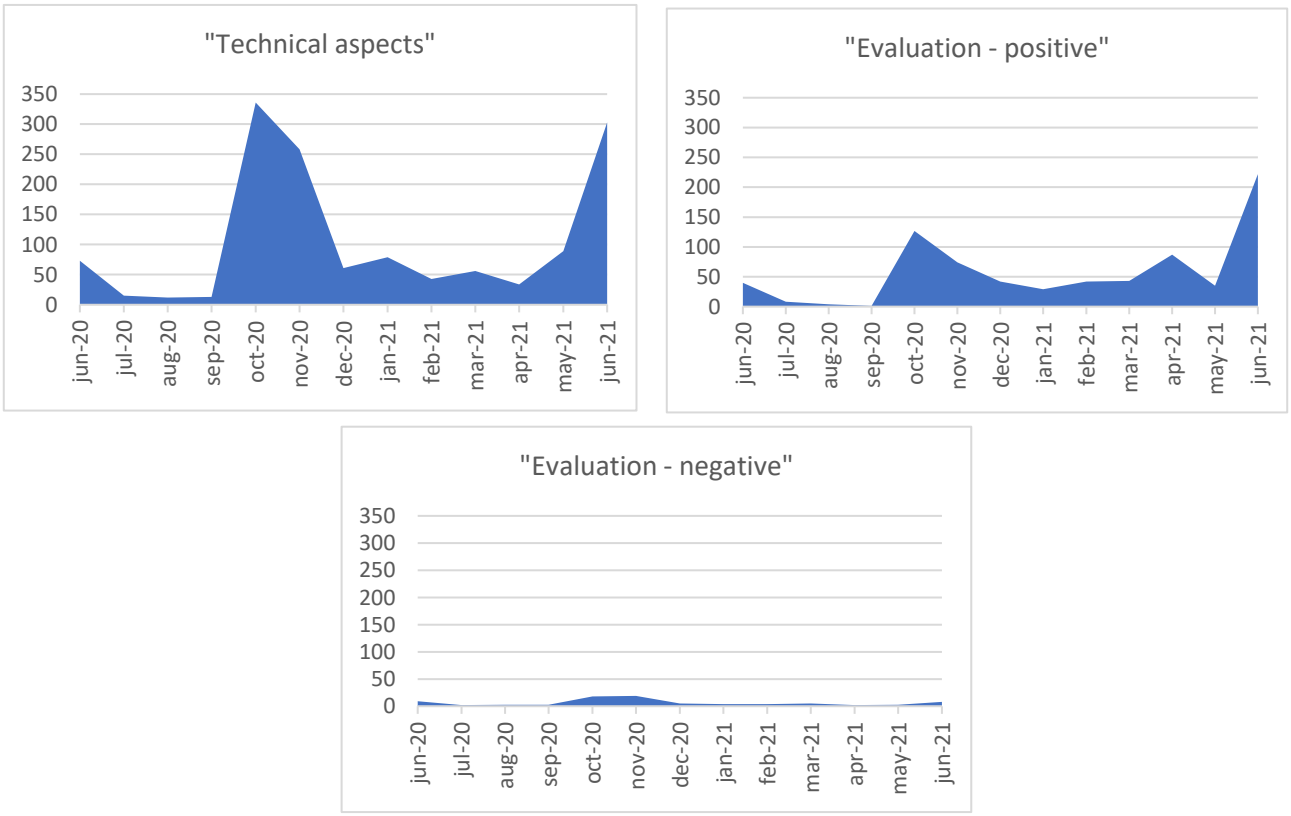


Average ratings for each category

Technical aspects	2.0
Evaluation - negative	1.4
Evaluation - positive	4.5

Interesting elements could emerge from considering how these categories spread across the considered timeframe, as pictured in the following plots of *Figure 9*.

Figure 9 - Number of French reviews per trigrams category throughout months



3.2.1 Interpreting the data

Starting with the category which has the lower numbers, namely "Evaluation – negative", not very significant data seems to emerge. A relatively larger concentration of reviews having the trigram falling into this category was published around the period of the TousAntiCovid rollout. This result is coherent with the analysis of the previous paragraphs, where most of the 1-star reviews were published around the same period.

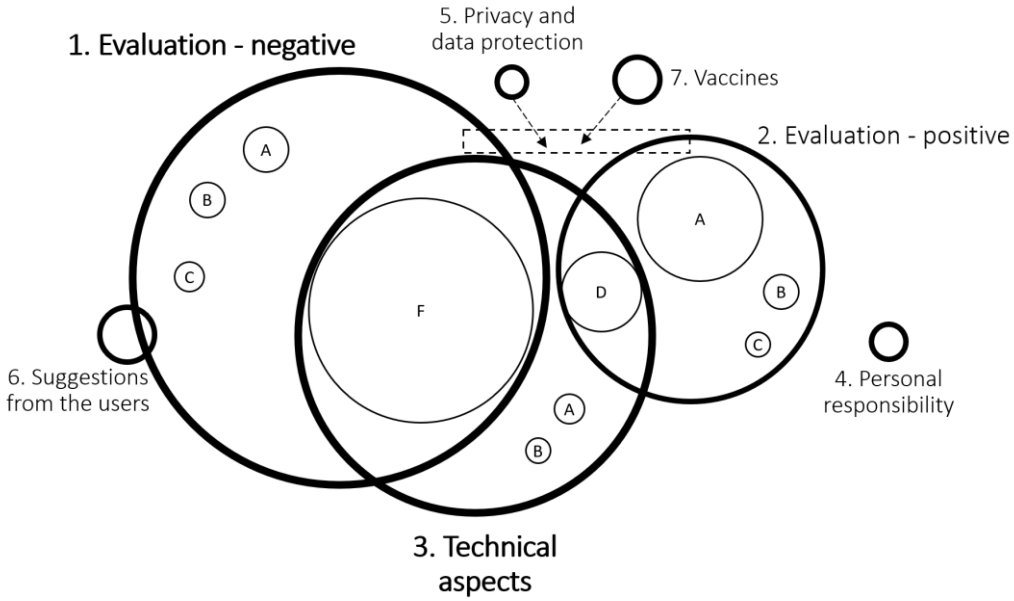
The "Evaluation – positive" category follows a similar pattern as well, with most of the reviews having trigrams of this category being published towards the end of the considered timeframe. With respect to the "Technical aspects" category, the highest peak is registered when TouAntiCovid was released, suggesting that many users commented on technology-related aspects, especially with respect to the new and significant update of the app. The role of updates, as shown by the second-highest peak in the figure, was quite relevant also towards the end of the considered period.

Besides confirming some of the trends that emerged from the previous descriptive analysis, considering the most recurrent trigrams offers initial suggestions on the topics that most largely interested all the users that posted reviews from June 2020 to June 2021. To better understand what actually users think and write about these topics, it is necessary to make a step further and zoom in a little more.

3.3 Zooming in even more: thematic analysis of most liked French reviews

This last step in the analysis, as stated at the beginning of the section, was performed on a selection of 100 most-liked reviews. As happened in the previous chapter, a sort of map of the most recurring themes and related elements is pictured in *Figure 10*. A bigger circle means that more items were coded within that theme or element. The interaction between different major themes is also shown. The upcoming paragraphs will describe themes' elements reporting examples of the users' reviews that could help stress the most relevant matters.

Figure 7 – Map of themes and elements in French reviews



1 Evaluation - negative	2 Evaluation - positive	3 Technical aspects	4 Personal responsibility
1 A Test	2 A Digitalize paperwork and news	3 A Bluetooth	5 Privacy and data protection
1 B Useless app	2 B Easy to use	3 B Battery of the phone	6 Suggestions from the users
1 C Unclear elements	2 C Good idea behind	*D Good technical features*	7 Vaccine
F Errors & bugs	*D Good technical features*	*F Errors & bugs*	

3.3.1 The "Evaluation - negative" theme

The most recurrent theme is "Evaluation - negative". The most relevant element of this theme regards reviews reporting technical problems, bugs, and errors with the app (group F). That is why this relevant element is shared with the theme dealing with the technical aspects of the technology covered in the reviews. It is interesting to notice that complaints about technical issues were published both for the StopCovid app and the TousAntiCovid one, which can be deducted from the publishing date.

> *Same message as many others, when I want to activate monitoring: \"An unlisted error has occurred\".*
>
> Posted on 22/09/2020, 1 star

> *The app, after a few days, is no longer active. When I try to restart it, it crashes. Forced to uninstall - reinstall at least once a week... And it was already happening to me this summer with Stop-Covid. How is it possible that it still hasn't been fixed? I'm obviously not the only one having this problem.*
>
> Posted on 05/11/2020, 2 stars

> *The application stops after for a few hours, for no apparent reason and impossible to restart it without reinstallation, restarting the smartphone is never enough.*
>
> Posted on 05/01/2021, 1 star

When writing negative reviews, users also tackled some experienced issues with registering COVID test results on the app (group 1A); while others stated that to them the app seemed useless (group 1B).

> *We have been 3 tested positive. Only 1 person was able to register thanks to the bar code received by email. The other 2 received their barcode by mail 7 days later, so too late to register! Only 1 in 2 people received the contact case alert. Too bad you need a barcode received by mail to declare yourself. Very very unfortunate.*
>
> Posted on 04/01/2021, 3 stars

> *False and useless application. I have been in contact with 3 positive people (minimum) including two under my own roof. My companion said he can't do anything for 2 months on the application, but it always tells me that I haven't been in contact with positive people. So what is the purpose of this application exactly?*
>
> Posted on 31/03/2021, 1 star

It is interesting to notice how some users wrote about the fact that the app was too complicated and difficult to use (group 1C). What is relevant to stress is that all the reviews that covered this issue were related to the TousAntiCovid app.

> *Very bad experience with this site. After opening the test QR code, Unable to transfer it to a mailbox for printing. I find this app very unclear, very messy.*
>
> Posted on 03/06/2021, 1 star

3.3.2 The "technical aspects" theme

The second most recurrent theme is "technical aspects". As it emerged from the trigrams' analysis, many reviews from French users engaged with technical-related aspects. As the "bug and error" element showed in the previous themes, many users expressed negative opinions when dealing with these kinds of topics. However, some other users also stressed the pros and advantages of the technology, focusing especially on new updates released for the app.

> *I change my opinion after the last update of November 2: the certificate generator is now integrated into the application instead of being a link to the site.*
>
> Posted on 03/11/2020, 4 stars

> *The successive updates have considerably improved the reliability of the application and the range of features offered (such as the derogatory travel certificate, now simple and quick to complete with automatic saving of fields).*
>
> Posted on 22/11/2020, 4 stars

Users also reviewed elements related to the functioning of the phone, such as Bluetooth (group 3A) and the battery (group 3B). As the following two excerpts on the battery of phones show, a unique perspective on this issue did not emerge, as it is highly dependent on the device of the user and less on the app software.

> *as soon as the bluetooth is deactivated (low battery for example), it is impossible to reactivate the app. You have to delete the data for it to work again. What about contacts if they are deleted?*
>
> Posted on 27/01/2021, 3 stars

> *A notable disadvantage: the battery drops at high speed. You have to recharge the smartphone every day even if you don't use it much else. So deactivate the application at home when you don't have a visitor.*
>
> Posted on 06/04/2021, 3 stars

> *As for the battery, the app has an invisible effect on my phone, I'm quite amazed by the other reviews.*
>
> Posted on 02/11/2020, 5 stars

3.3.3 The "Evaluation - positive" theme

Moving to the third most recurrent theme, what is very interesting to stress here is the "digitalize paperwork and news" element (group 2A). Many users expressed their appreciation for the new features of the TousAntiCovid app related to the digitalization of documents, for moving around or entering shops for instance, which were initially required to be printed and later became digitally available on the app. Furthermore, as previously explained, the TousAntiCovid app introduced news and statistics sections in the app, which were also largely appreciated.

> *All the necessary information and services in a single app (more convenient than juggling between government sites, Ministry of the Interior, Public Health France...). We have an overview of figures, national and local, and news updated daily. Ability to create, save and manage your certificates (like your tickets in the SNCF application).*
>
> Posted on 10/02/2021, 5 stars

> *The application is well done, pretty and educational. It's a good thing to be able to follow the numbers. In addition, the certificate generation in the app is great! It's integrated and automatic filling, we easily find the certificate, at the top! No more going through the website and digging through downloads.*
>
> Posted on 02/11/2020, 5 stars

While reviewing the app, as already mentioned in the previous paragraph, users also expressed positive opinions because they were experiencing no technical issues (group D) compared to other users from whom they probably read negative reviews.

> *Satisfied that the application is (finally) compatible with my phone (Galaxy J7). For the moment everything seems to be working fine without draining my battery, but I haven't had many occasions to use it so to follow.*

Posted on 24/03/2021, 4 stars

I find people very hard on the app. I find it simple enough to be understandable.

Posted on 05/06/2021, 5 stars

3.3.4 Other minor themes

Next to these three most represented themes, smaller themes offer interesting elements for the analysis as well. With respect to the "suggestions from the users" theme, it emerges that some users engaged in the proactive activity of writing about possible updates and changes to make the app better. It is interesting to notice how users suggest new features to make the use of the app easier and more interactive.

It would be nice to have a way to check that the application is working correctly, for example by adding a statistics tab which displays how many \"Bluetooth messages\" have been sent to or received from other phones. It would also be desirable to communicate more (not only in the application) on the reason why the location permission is requested, namely because it is necessary for Bluetooth Low Energy, and not to trace us by GNSS.

Posted on 05/06/2021, 5 stars

Small suggestion: add an Android widget that can be placed on the home screen to activate and deactivate the application with a single click (this would avoid having to open the app and press the button each time).

Posted on 11/01/2021, 4 stars

Another minor theme that could be interesting to develop a little further is the one related to vaccinations. The previous sections showed how a large share of users' attention coincided with the introduction of the vaccination certificate on the app. The qualitative analysis of the 100 most liked reviews confirms that, because even if they were just posted in July 2021, some reviews on the vaccination certificate entered the group of the 100 most liked in the whole considered period. Reviews covering this theme were in some cases neutral, while in others expressed either a positive or a negative evaluation of the app.

For people who can't scan their QR Code: I had the same problem scanning the QR Code of my vaccination certificate. I called the toll-free number listed on the app. I had someone almost immediately. The person advised me to download and use an app that scans QR Codes. What I did, and I was able to add my certificate to TousAntiCovid.

Posted on 19/06/2021, 5 stars

To a smaller extent, users talked about everyone's responsibility when using the app, sometimes calling other people to download it, and some others complaining about the voluntariness of the intervention. To an even smaller extent, users also mentioned privacy a data protection-related matters, expressing both positive and negative evaluations.

Also as an independent computer security professional, I can tell you that it is a well-made application, which works with so-called Zero Knowledge security: the application does not know who you are, the server does not know who you are: nothing to hack = high security.

Posted on 03/06/2020, 5 stars

After multiple tests, this software is too invasive. It dialogues with the outside even when it is deactivated, it overrides any blockages such as software firewalls and collects far too much useless information for the fight against the pandemic. This is, again, an attack on \"freedom\" in full massive deployment by the state. I regret that there is no regulation at European level.

Posted on 10/11/2020, 5 stars

3.3.5 Interpreting the data

Despite the negative evaluation theme being the most represented, the theme on technical aspects really stands out, as shown by the large circle in *Figure 10*. Such hierarchy is in line with the findings of the trigrams' analysis. When grouping trigrams into categories, most of them fell into the one related to the technicalities of the French DCT solution, as presented in the previous section.

The negative evaluation and the technical aspects themes are highly connected by the errors and bugs experienced by users. Other technicalities were also discussed in the analyzed reviews. One of these was the impact of the CTA on the battery of the phone. With respect to this topic, users' positions were more heterogenous than those on errors and bugs. Some users stressed how using StopCovid or TousAntiCovid drained their smartphone's battery, while others reported no significant impact on it. It is interesting to notice how the experience of different users with the app, and therefore all DCT policy, changed based on a technological artifact they own, on whether they own a newer or older phone.

Other non-fully digital issues with the CTA brought some users to express negative opinions on the app. It is the case of problems in uploading test results or even getting test results to later upload. Once again, the digital dimension and the non-digital dimension of the intervention are strictly related and impact the users' experience of the app, and therefore their opinion of it.

The analysis of reviews showed how opposing opinions were also posted with respect to the many features that the app could offer. Many users praised the new functionalities of the new TousAntiCovid app, while others lamented it was too complicated. This element shows how, when carrying out a policy through digital technologies, the response of the public is not just dependent on their technological tools, but arguably also on their level of skills and familiarity with these types of elements.

It must be stressed how the elements of the positive evaluation theme were fewer than those of the two other major ones. With respect to the minor themes, some interesting aspects emerge that could help a deeper comprehension of users' opinions on the app. Some people posted suggestions to improve the app, interestingly referring to both the old version and the new version of the app. Another element that is worth mentioning is related to reviews on vaccines. As already stated, the vaccine theme entered the group of

most-liked reviews even if it was introduced in the last weeks of the considered timeframe. This element shows how an additional non-DCT-related element of the app was significantly discussed by users, just like the excerpts in the element "digitalize paperwork and news".

The topics and elements that also received no attention can tell something about the way users engage with the CTA. The debate on the centralized and decentralized approach, and therefore on digital sovereignty, was almost completely absent despite the previous pages have shown how much these debates characterized the early phase of the CTA development and the actors involved there. This trend is in line with the one that emerged in the analysis of the Immuni case.

3.4 A further consideration on the use of the French CTA: the role of local healthcare authorities

Unlike what happened in the Immuni case study, the gathered empirical materials do not offer many chances to elaborate further on the using phase of the French CTAs. However, just like the Immuni case, a more specific focus on the role of local healthcare authorities should be provided.

While in the previous chapter the designed role of the local healthcare authorities was a pivotal one in the early DCT strategy, in France these actors played a secondary role. As *Figure 2* at the beginning of this chapter already showed, a French user who tested COVID-19 positive had many ways to activate the signaling procedure through the app, unlike it initially happened in Italy, where each user needed to rely on local healthcare authorities.

Also, from the analysis of users' reviews, it seems that the role of these actors was not largely considered when expressing experiences or opinions on the app. Furthermore, *Interviewee R* described how the DCT strategy was mainly carried out by the National Government, with very low involvement of local healthcare authorities, who were mainly in charge of the manual contact tracing procedure.

> *DCT was really up to the National Level. We have what we it is called the LRS, so it is the localized healthcare authorities, and they were in charge of the manual contact tracing in theory… except that, because we never had the pandemic before, they were really understaffed, and the manual contact tracing was quickly saturated. They were not able to do many stuff, and they were just trying to keep in touch with every new case.*
>
> Interviewee R

4. StopCovid and TousAntiCovid's design, implementation, and use wrap up

This chapter has tried to reconstruct the process that brought about the development of a technological solution for implementing a DCT strategy in France. It has been described how the early phase was managed almost exclusively by the National Government and the research institute Inria, which raised some critics from experts involved in the computer science field. Furthermore, just like in Italy, the leadership of the whole project was on the Secretary of State, who was in charge of digital issues in the country.

The technical implementation of the designed CTA did not run smoothly, since France decided to develop its

own centralized protocol, refusing to use the decentralized Apple and Google's one. These issues have been attentively tackled in chapter number four. On this topic and on the role of the two US tech firms, the French parliament largely debated before issuing the approval of the centralized tracing strategy. Most of the interest of the MPs pivoted around the defense of national digital sovereignty, which was the main reason for developing a US firms-independent solution.

Conversely, this topic was almost completely absent in what emerged from the analysis of users' reviews, which tackled a series of different matters. Users largely reported issues with the technical aspects of the app, mainly reporting bugs and errors when using StopCovid or TousAntiCovid. Interestingly, users largely appreciated the additional features of the app that were introduced when the Government decided to rebrand the StopCovid app into the TousAntiCovid one.

In general, users of the app seemed to be highly polarized when expressing ratings on the app, with 34.5% of them rating it with 1 star and 37.3% with 5 stars. Interestingly, greater approval of the app seemed to raise towards the end of the considered period, when vaccine-related functionalities were added, pushing contact tracing-related ones to the side even more.

The switch from the StopCovid app to the TousAntiCovid one seemed to have impacted positively the diffusion and the perception of the French CTA. However, it must be noted how, to increase the numbers and the reputation of this solution, the tracing functionalities that were initially designed as core elements were largely marginalized.

4.1 Succinctly picturing the French DCT strategy

The development of the French DCT strategy was a very articulated one. First of all, France refused to collaborate with Apple and Google. This problematic relationship between these two actors initially compromised the deployment of an easy-to-implement DCT strategy. However, how it has been described in this chapter, France was able to circumvent this issue by excluding the two tech firms from the design and implementation of its CTA by relying on a solution developed by the French institute, Inria.

Furthermore, additional issues in the French DCT strategy emerged with the low number of downloads of the StopCovid app. As has been presented in the previous pages, in October 2020, the French Government decided to restyle the CTA, changing its name and its features. As the reviews analyzed in this chapter showed, the new updates were well appreciated by the users. The fact that the main tracing feature of the CTA was sided by additional features like statistics or news updates contributed to putting the CTA back on track, at least from the point of view of the numbers of downloads and users' evaluation.

Based on the same scheme that was introduced for Immuni in the previous chapter, *Figure 11* pictures the problematic relationships just described, namely the issues between national public authorities and Apple and Google, and the users of the app with the first version of the CTA, StopCovid. These problems initially compromised the French DCT strategy, providing those "shakes" that made it "fall". Then, *Figure 12* pictures

how a sort of equilibrium towards the deployment of a national DCT strategy was restored through the elimination of Apple and Google from the process and the rollout of the new app, TousAntiCovid.

Figure 11 – The early "fall" of the French DCT strategy due to problematic relationships between actors and actants

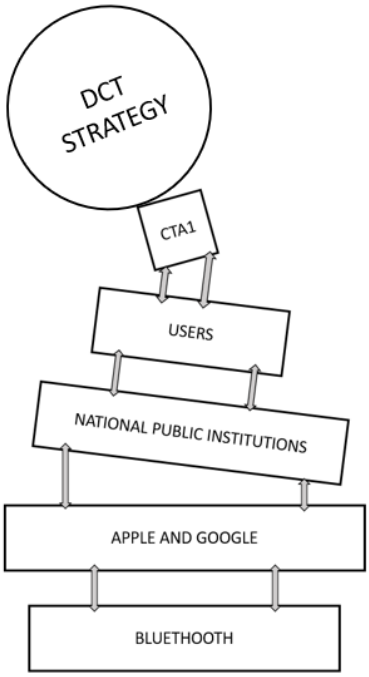
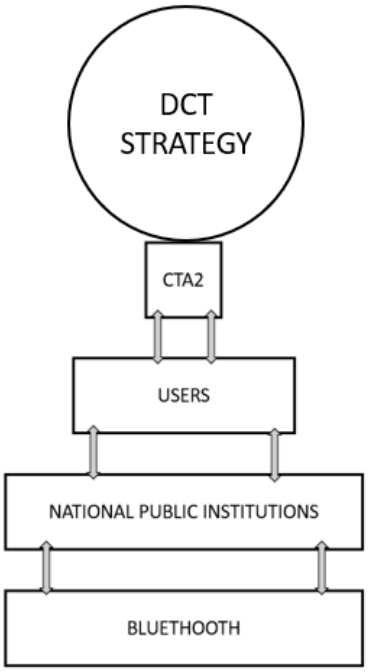


Figure 12 – The later "equilibrium restoration" of the French DCT strategy due to Apple and Google exclusion and new app release



Chapter 7 – CoronaWarnApp and digital contact tracing in Germany

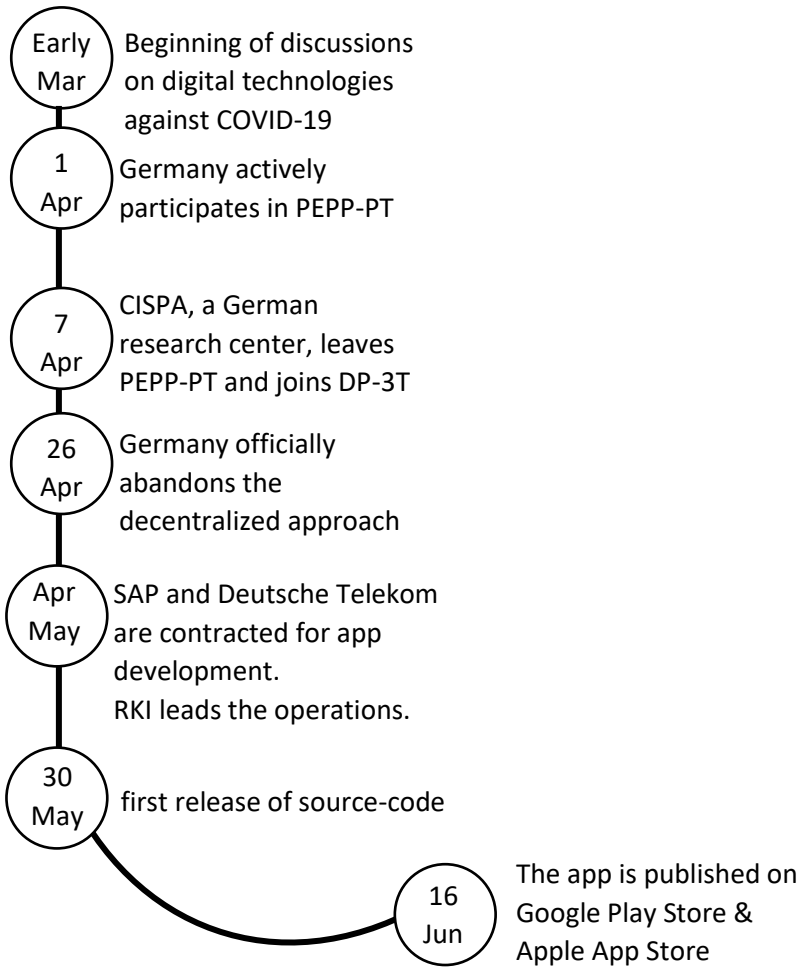
The third and last case study to better explore the design, implementation, and use of DCT technologies in Europe is Germany. As for the French case, the empirical materials available for the German case are fewer than the ones gathered for Italy. Therefore, the approach and the structure of this chapter would be similar to the previous one. It should be stressed how, with respect to the analysis of France's DCT strategy, the empirical materials on Germany can count on interviews with relevant actors who were more closely involved in the process of design and implementation of the CoronaWarnApp (CWA). On the other hand, the materials on the political debate that developed in Germany around this issue are less rich compared to the French ones. Despite these differences, once again, the logic of presenting the materials has been kept equal. On the one hand, the chronological order of the development of tracing technologies in Germany is a pivotal reference point. On the other, the role of relevant actors in the whole process works as a guiding principle. As happened in the previous chapter, the documents cited in this chapter come from *Table 3* in chapter 3, where they were properly referenced. To ease reading, the long list of references will not be reported again in this chapter. Interviewees' descriptions and categorizations are reported in chapter 3 as well, in *Table 7*, but they will be briefly repeated in the following text.

1. The design of a digital contact tracing solution for Germany

1.1 Switching protocol: from centralized to decentralized

In chapter 4, while describing the initial development of debates around DCT technologies in Europe, the role of German actors, both from the public and the private domain was already stressed. The Robert Koch Institute (RKI), namely the main German public scientific institution in the field of biomedicine, was highly influential also at the continental level, but in Germany, it largely guided the whole process that brought to the launch of the CWA in June 2020, as pictured in *Figure 1*.

Figure 1 - Timeline of CoronaWarnApp development



One of the initial issues that characterized the design of the German DCT solution was the debate on the centralized and decentralized approach, which largely interested several EU actors, as also described in chapter 4. The interviewee from the RKI explains how this debate was largely present within the Institute as well.

> *So, the discussion started back in the days, and I think the first weeks and months there were strong discussions about which technology to use. You probably already dive deep on the centralized approach versus the decentralized approach. The group that formed, and RKI collaborated also, focused in the beginning mainly on the centralized approach, and then there was a big civil society discussion on data protection, for example, and it was decided to switch to the decentralized approach*
>
> *[…] I think there were different positions within the RKI. And I think it's also important to discuss the different point of views. On the one hand, it may be very handy to have a centralized approach, because you would get even more information that could be used for outbreak monitoring for example. On the other hand, there was the decentralized approach, and it was very data protection friendly, and it may add that to a vast number of downloads.*
>
> RKI

The debate on which one of the two approaches should be used for the official German app was solved on April 16th, 2020, when chancellery minister Helge Braun and health minister Jens Spahn jointly announced that Germany would have built its app following the decentralized approach (Lomas, 2020a). This decision by the Government introduced to the development process new, largely significant, actors. The interviewee from the RKI explains what kind of responsibilities these new actors took in the project.

> *With the decision to switch [ed. from the centralized to the decentralized approach], the project was given to big industrial partners. They were SAP and Deutsche Telekom, that were responsible of developing the technological part of the app, in strong collaboration. The Fraunhofer Institute was responsible for the Bluetooth measurements. It was... it is an ongoing process, because there were very unique features that were never used before. They just use the measurements and improve the CWA over time. And RKI was mainly for the epidemiological questions related to the CWA.*
>
> *[…] By the end of March, and the beginning of April, it was decided by the government that the decentralized approach should be focused, and more or less the next day we had the first meeting with SAP and Telekom. And we started the decentralized project, and I guess in 40 days the CWA was built and released to the app store.*
>
> RKI

From the interview with the SAP's employees also emerges how sudden was the change and how time constraints were a significant factor.

> *Then suddenly there was a public change when our federal Minister for health announced: "okay now we do it differently" and then SAP and Deutsche Telekom got the request to develop it as fast as possible.*
> *[…] Unfortunately, at least from my point of view, I don't have that many details on the actual process when it was done between SAP and the German Government or the RKI, which is our epidemiological institute. Even if I had this information, probably I wouldn't be allowed to tell you because it's confidential.*
>
> RKI

From the official documentation released with the app's code, it is possible to know a little bit more about the specific tasks that the Government required to the two firms. The main request was to develop a tracing app as an open-source software. Deutsche Telekom was in charge of "providing the network and mobile technology and will operate and run the backend for the app in a safe, scalable and stable manner". On the other hand, SAP was "responsible for the app development, its framework, and the underlying platform" (Corona-Warn-App: Documentation).

With these new actors involved, but, most importantly, after the switch of the protocol, the leadership of the whole project changed and became more clearly defined with respect to what was happening while still involved in the centralized project. The interviewee from the RKI precisely recalls it.

> *At the beginning, for the centralized approach it was more or less some kind of intrinsic motivation. People invited other people to take part. It was this very special time. We don't know how the pandemic would develop and a lot of different stakeholders were really highly interested in collaborating and giving some added value to the project. So, the guidance was mainly back in the days at the Fraunhofer Institute. After the switch to the decentralized approach, it was a decision by the German Government more or less. On the one hand it was the Health Ministry or the Chancellor, they had close calls and talks with the head of Ministry of Health at the RKI. […] At the end, leadership was taken by the Health Ministry, more or less, which also gave some good guidance and was also important for the public opinion of the CWA, and also the decision to further develop was also quite important.*
>
> RKI

1.2 Two main guiding principles: security and transparency

Under the leadership of the health Ministry through RKI, SAP and Deutsche Telekom started working on the design of the German CTA by the end of April and the beginning of May 2020. The public relation and communications activities of the two firms were quite intense around that period. In the official press releases, the attention toward users' data was largely stressed.

> Particularly with regard to data protection and security, there has been very close cooperation with key public institutions such as the Federal Office for Information Security (BSI) and the Federal Commissioner for Data Protection and Freedom of Information.
>
> SAP, 17 June 2020

> We coordinate every step of development with the German Federal Office for Information Security. The Federal Commissioner for Data Protection, BfDI, has also been closely involved from the outset. Together, this leads to a high level of security.
>
> Telekom, 15 May 2020

Furthermore, transparency through open-source software, namely publicly available software, was another largely stressed issue in the public communication of the project by the two firms. The centrality of open-source software was also stated in the official app documentation as an explicitly required element by the German Government when contracting the two firms (Corona-Warn-App: Documentation).

> This approach [ed. open source] was chosen for the Corona-Warn-App in order to create trust through technological transparency and thus also to strengthen the acceptance of the app among the population. In addition, the disclosure and verifiability of the source code gives everyone the opportunity to actively contribute to the success of the solution, for example in the form of correction or improvement suggestions.
>
> Telekom, 18 May 2020

> Together, we are working flat out on an open source solution. This is a central demand that data protection and the public place on us: create transparency, offer no chance for backdoors. This is how we create trust. We will keep you informed about the progress on the developer platform Github. In the open source community the motto is: release early, release often. Therefore we report from the early stages of development and will continuously publish milestones on Github. Programmers and other interested people can exchange ideas with us.
>
> Telekom, 15 May 2020

Transparency through open source was considered to have a positive impact on people's trust in the app not just by the two involved firms, but also by *Interviewee U*, a scholar who participated in the development of the protocols at the EU level and then advised SAP and Deutsch Telekom.

> *So, there was essentially this decision to go with the decentralized solution, there was the implementation that was led by SAP and Telekom, and we kind of supported them on security things, over a number of rounds and so on. And I guess then also Telekom and SAP chose this GitHub-base publication approach, which was pretty novel in their context - I guess - and it worked relatively well in incorporating the stakeholders and the public, and really help you know to get support by really privacy minded people in the German public, because they could look into the system and see that things were implemented as specified and so on. And I think this was pretty important, and I don't think this would have been something that SAP or Telekom would have done for anything else, if hadn't be for this kind of DP-3T GitHub stuff that went on before.*
>
> Interviewee U

The two principles of security and transparency came up also in the rather ideological and heated debates that developed around the CWA during a Bundestag session on May 7, 2020. The MPs started debating on the features of the under-development app, following a motion by the AfD party titled: "Reestablish fundamental rights – no data collection by a Corona app". The risks of pervasive surveillance and limitation of personal freedoms were stressed by the supporters of the motion. On the other hand, the majority of the Bundestag underlined the core values of the app under design, adding freedom of choice to the two mentioned so far.

> *A very important criterion is the so-called principle of double voluntariness, which means that when this app comes, it is voluntary for everyone to install it, and it is also voluntary to donate data or even enter a message in this app. This is a very fundamental principle and distinguishes this app, the German approach, from many other approaches in the world and - unfortunately, one has to say - in Europe.*
>
> MP Christoph Bernstiel

> *But for us as a social democracy, the following applies: no central approach, but a decentralized approach, maximum data protection.*
>
> MP Claudia Roth

> *And I would like to emphasize at this point: Use of the app is voluntary and will remain voluntary! The user data should always be stored decentrally on the devices so that they are better protected against external*

access. A recording or evaluation of GPS location data does not take place; the functionality of the app should also be understandable for everyone.

MP Stephan Pilsinger

2. The implementation of the DCT solution in Germany

Since Germany ultimately decided to rely on the decentralized protocol designed by Apple and Google, most of the lower-level implementation was carried out by the two US firms with the Exposure Notification Framework (ENF), as *interviewee T_1* from SAP explains.

So, the centralized and decentralized thing was decided up front, so that was a given. Also, it was pretty much clear since Apple and Google decided on the centralized and decentralized approach by introducing their framework, that was basically there. Of course the rest on top, how the application looks, features that need to come on top of this framework, how the use flow works and stuff, that is of course something that has been designed by us, with Deutsche Telekom, RKI, the Federal Ministry of Health and all the stakeholders of course they needed to agree on everything they needed to be part of the whole process, but the foundation was clear.

Interviewee T_1

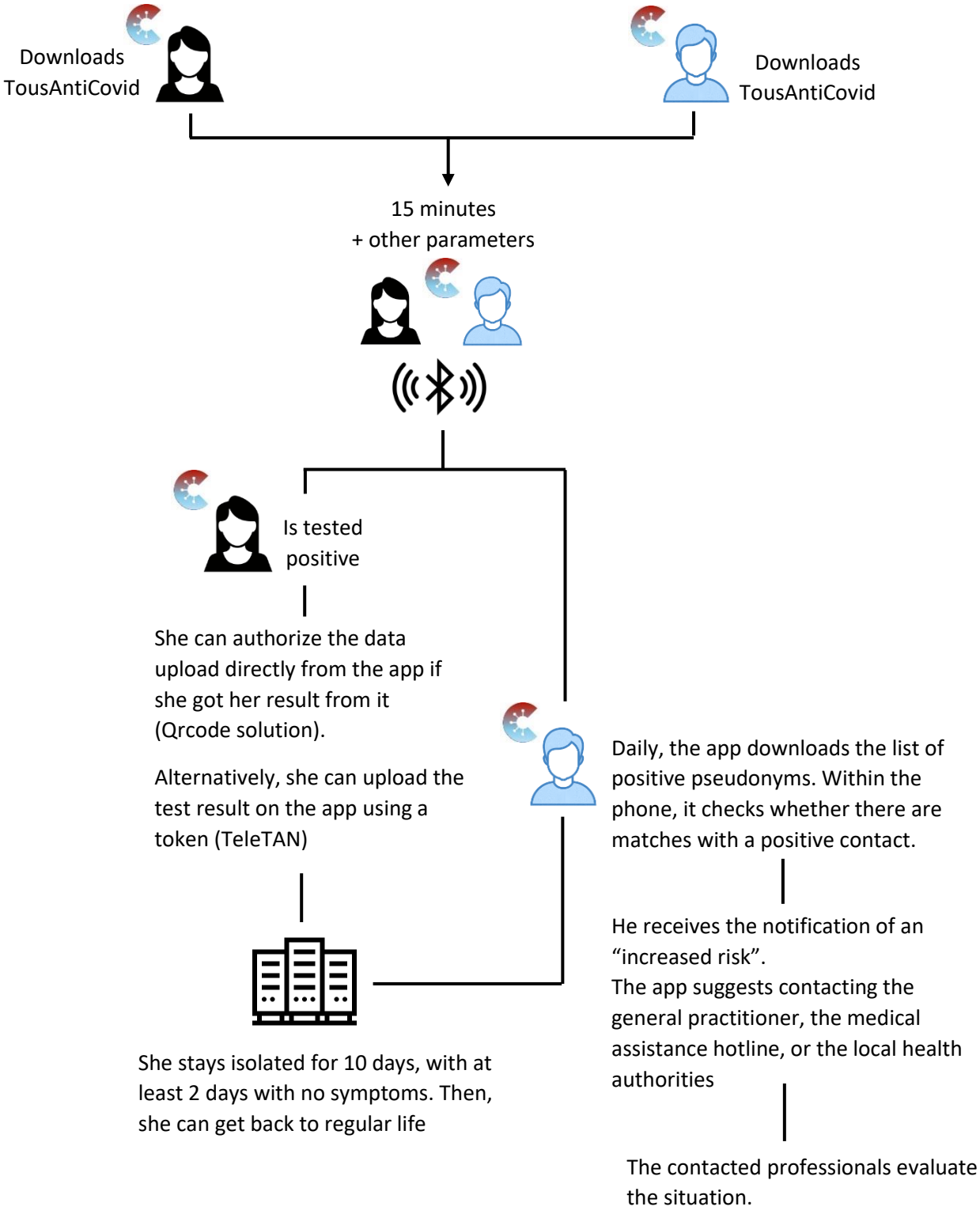
The interviewee from SAP also explained how the implementation activities worked.

So, there were different work streams in the whole project. As said, we had two companies involved who actually did the implementation, that is Deutsche Telekom and SAP. And, of course, the differentiation between Deutsche Telekom and SAP is one thing […]. Then there were of course several teams within the companies who did the implementation of different components. So, we have the app, then we have several components, then we have the verification of several components, and also in the background the connection to the test centers, for instance. They were of course organized in different teams. Our task was mainly to take care of the open-source publication process and to manage everything that from a policy perspective, community management perspective.

Interviewee T_1

As already mentioned, the design and implementation of the app happened quite quickly. It has been already stressed how the German privacy authority issued opinions and guidelines while the technology was under development (BfDI). The official source code of CWA was initially available online on May 30th, then the app was finally released in digital stores on June 16th, 2020. *Figure 2* shows the designed tracing process available through the implemented CWA at the launch. With respect to the two previously analyzed tracing procedure, the German one, since the beginning, offer multiple ways to signal the COVID positive status on the app, arguably making the whole process less articulated. Furthermore, the CWA relying on additional parameters besides distance and time of exposure presented to users different "risk levels" for encounters with a coronavirus-positive person. From the general point of view, the whole procedure is more similar to the Italian one, than to the French one, because of the type of underlying protocol implemented.

Figure 2 - How the digital tracing procedure works with CoronaWarnApp



2.1 The process of continuously updating the CWA

Both the previously analyzed CTAs underwent constant updating, mainly for bug-fixing purposes. However, the CWA has been updated month after month with relevant features, arguably similar to the ones that were added to the StopCovid app when it became TousAntiCovid.

While the firm that developed Immuni in Italy ended its involvement in the project once the app was implemented, SAP and Deutsche Telekom continued their partnership with the Government, as explained by one of the two interviewees from SAP.

> *So, the German Federal Government, RKI, basically contracted Deutsche Telekom and SAP to keep on working on the project. And also, during the time of the last year and plus [*ed. the interview was made on Octor 5th, 2021*], so more than one year, of course there were frequent and regular discussions with all the stakeholders on what needs to come in next, what were the priorities, what would need to be implemented, what needed to be extended. These can also be seen in the change logs, we also have this public blog, you probably already saw it. The features that have been added in the last year are pretty extensive. And, of course, that required the willingness of the stakeholders that contracted to Deutsche Telekom and SAP that they actually wanted that the software is extended in that way.*
>
> Interviewee T_1

The other interviewee from SAP explains how the process of continuously updating the app works, and how they get feedbacks also from the public and try to develop and implement new features in the app.

> *We are still continuing developing the app. We introduced vaccination status, event check, and cluster detection, and these kinds of functionalities that I don't see in so much of the other apps. There is some work for us, but in general I don't think there is any other app that spent much in development.*
>
> *[…] So we are working in the community, having discussions with the end-users, reading all the feedbacks from the stores, on GitHub we are having discussions with them, and all this kind of feedback is going into our internal development. We are having discussions with our product owners, product managers, with our stakeholders, do we want this or that feature? Functionalities, coming from our stakeholder, like RKI, what they want, what requirements that are coming in, like the vaccination status.*
>
> Interviewee T_2

Through this process, the initially developed app, which was mainly for tracing purposes, progressively added new features. As already mentioned by SAP, the RKI also stated that suggestions on possible new functionalities came from the users as well.

> *At the beginning it was pure proximity tracing, and we had the idea that the app should be used very possibly, like you switch the device on, put it in your pocket, and you don't look at the CWA. […] It was decided that we should further develop the CWA. Over time we implemented daily statistics on Corona pandemic into the CWA. There was some kind of contact diary in the CWA. In England the use of antigen test started in March, and it was quite important, so we also implemented the antigen test. In one of the last releases, we also implemented the digital vaccination certificate. So, it was really an ongoing process. The original aim of the CWA, namely focusing on a very passive tool in your pocket, changed due to demand from the Civil Society or politicians.*

[…] I think that what was really positive in the project was that we mostly listened to ideas of the GitHub community, online community, for improvements. For example, the contact diary was strongly wanted by the society, and also the rapid antigen test was more or less demanded, and we were able to build these improvements quite fast. I think it was important to change the attitude of the CWA, from a very inactive, passive, device, to an active tool.

RKI

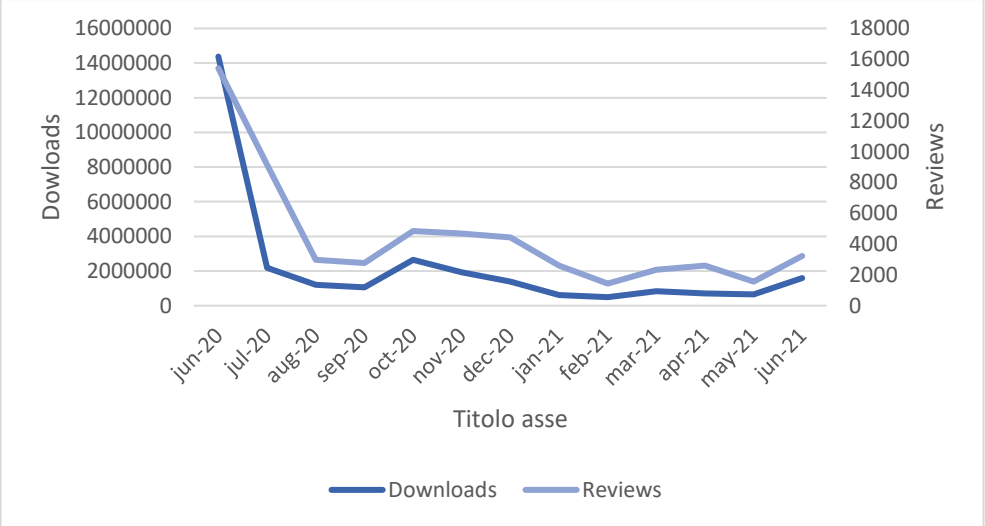
3. The official German contact tracing app in use

As for the previous two chapters, the users' reviews scraped from Google Play Store are now analyzed. The 61791 reviews of the CWA posted between June 2020 and June 2021 are initially considered through descriptive statistics; then, the natural language processing analysis is performed; finally, after having selected the 100 most-like reviews, thematic analysis is applied to try to understand main users' opinions towards the app.

3.1 A descriptive snapshot of German user's reviews

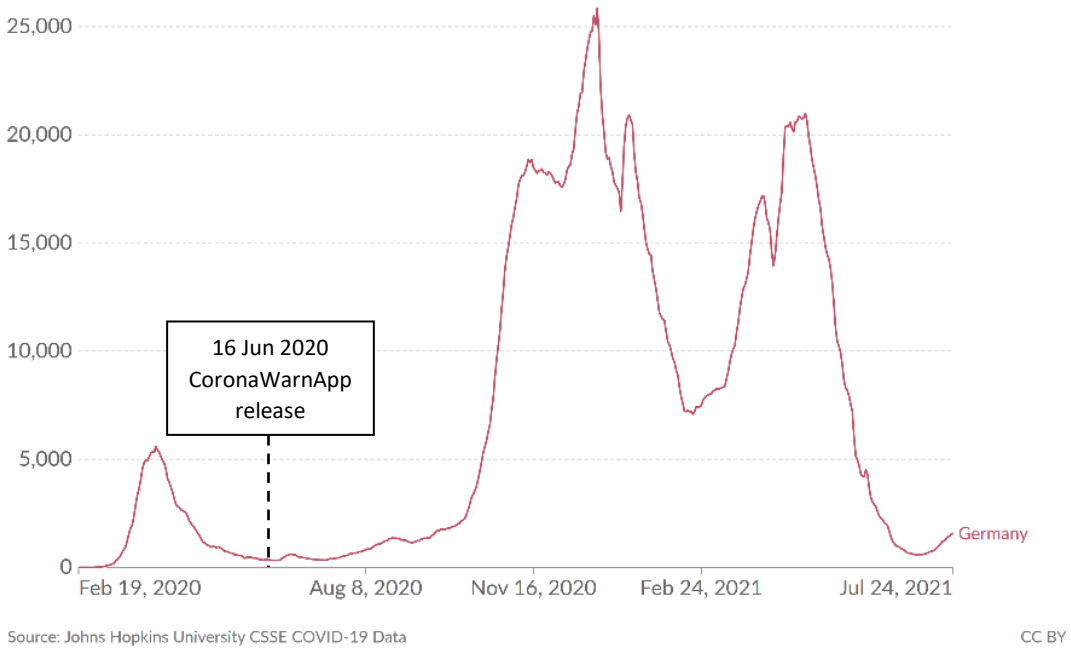
Unlike the French case, the German developers share on their official website some statistics with respect to the number of downloads. Therefore, as it happened for Immuni, it is possible to jointly consider how the number of downloads and posted reviews spread in the considered period. *Figure 3* shows that the trends of both these parameters are very similar. The highest peak in both downloads and reviews is registered right after the launch of the app in June 2020. A slight increase can be spotted around October and November 2020, but it is not as significant as the ones registered in previous cases. Similarly, the growth in reviews and downloads towards the end of the considered period, which emerged both for Italy and France, did not really happen in Germany.

Figure 3 - Number of CWA downloads and reviews by month



When considering the number of COVID-19 cases in the country, as pictured in *Figure 4*, very different trends emerge. It could be argued that most of the people that were interested in the app downloaded it right away, and later pandemic waves or new updates had a limited impact on increasing the number of users.

Figure 4 - Number of positive people in Germany throughout the months



Source: Our World in Data, https://ourworldindata.org/coronavirus/country/germany?country=~DEU, last accessed on 12/10/22

To add additional information to this descriptive picture, *Figure 5* shows the average ratings that users gave to the CWA app. Once again, the peak of the highest ratings is registered at the app's rollout. In the later couple of months, it decreased by almost 1,5 points and remained quite stable until April 2021, when it started to grow back. Looking more closely at the composition of the average ratings, as pictured in *Figure 6*, it emerges that most of the reviews were rated either 1-star or 5-stars, showing how in Germany as well the audience was quite polarized. Through *Figure 7* is then interesting to notice how most of the 5-star reviews were concentrated in the first month of release and then dropped significantly in the remaining months of the considered period. Conversely, 1-star reviews spread more homogeneously across the analyzed time frame.

Figure 5 - Average ratings of the German app through months

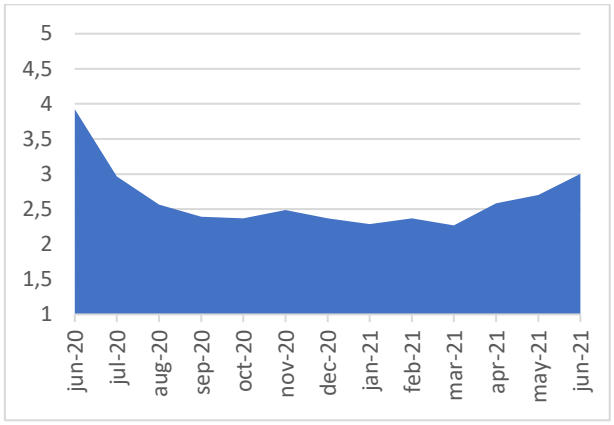


Figure 6 - Share of German reviews with different ratings

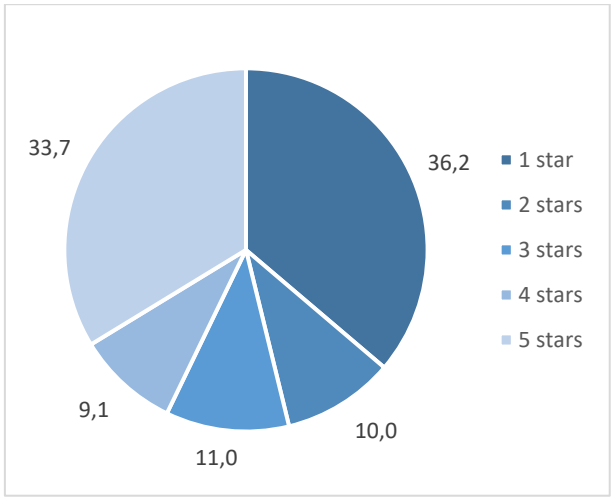
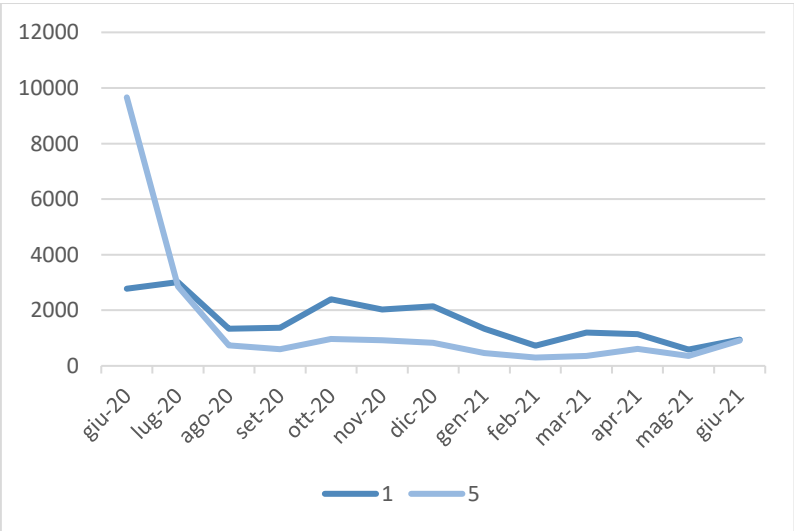


Figure 7 - Number of German reviews with 1-star or 5-star ratings throughout the months



3.1.1 Interpreting the data

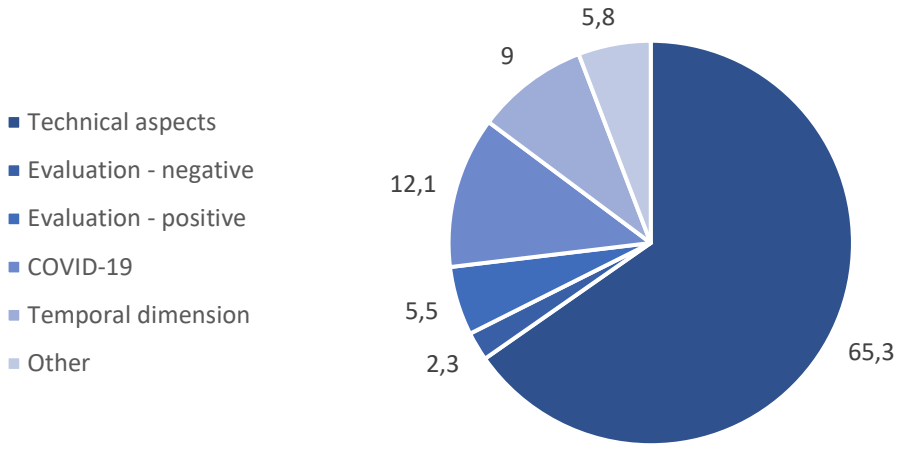
As already mentioned at the beginning of the section, unlike the previously analyzed cases, the descriptive statistics for the German app show that the most active period in the first year of app use was the first month. Many downloads and reviews happened during June 2020, when the user rating was also the highest. The fact that the development team constantly added new features to the app, as described in previous pages, could be one of the reasons why no significant peaks in downloads are registered in later periods. For instance, in France, the app was completely renewed in October 2020, so other people decided to download it. Conversely, in Germany, new features and characteristics were added month after month, week after week. Therefore, it is reasonable to explain the lack of download and review peaks with this different, more progressive, approach to app updates. Arguably, new German users decided to download the app not even for large new communication campaigns, as it happened for Italy since the evolution process of their CTA has been continuous and quite constant.

3.2 Zooming in: most recurrent topics in German reviews

The second step in the analysis, which characterized the previous two chapters as well, is the n-gram analysis. The *Appendix* reports the list of the top30 most recurring bigrams and top20 trigrams. The top20 trigrams have been manually classified into categories. All the five already introduced categories were useful to analyze the German trigrams, namely "Technical aspects", "Evaluation – negative", "Evaluation – positive", "COVID-19", and "Other". Furthermore, another one was added, which is the "Temporal dimension". This category groups trigrams that include the word "day". Most of these trigrams are part of reviews that talk about the time spent waiting for signaling own positive status on the app, receiving alerts from risky encounters with others, or issues related to new updates. With respect to the "Technical aspects" category, the trigrams are mainly related to Google issues, errors in communications and updates, and QR scanning. Just one trigram per category falls into the positive and negative evaluation ones; while concerning the "COVID-19" category, the trigrams are related to coronavirus-positive tests or risky encounters. Finally, the "Other" category contains a trigram with the name of the app: "corona, warnen, App".

Figure 8 pictures the share of these categories among the top20 trigrams. The largest part of them falls into the "Technical aspects" category. As anticipated, the two evaluation categories are very small, while in the two previously analyzed cases they were largely more significant.

Figure 8 - Most recurrent trigrams categories in German reviews and related ratings

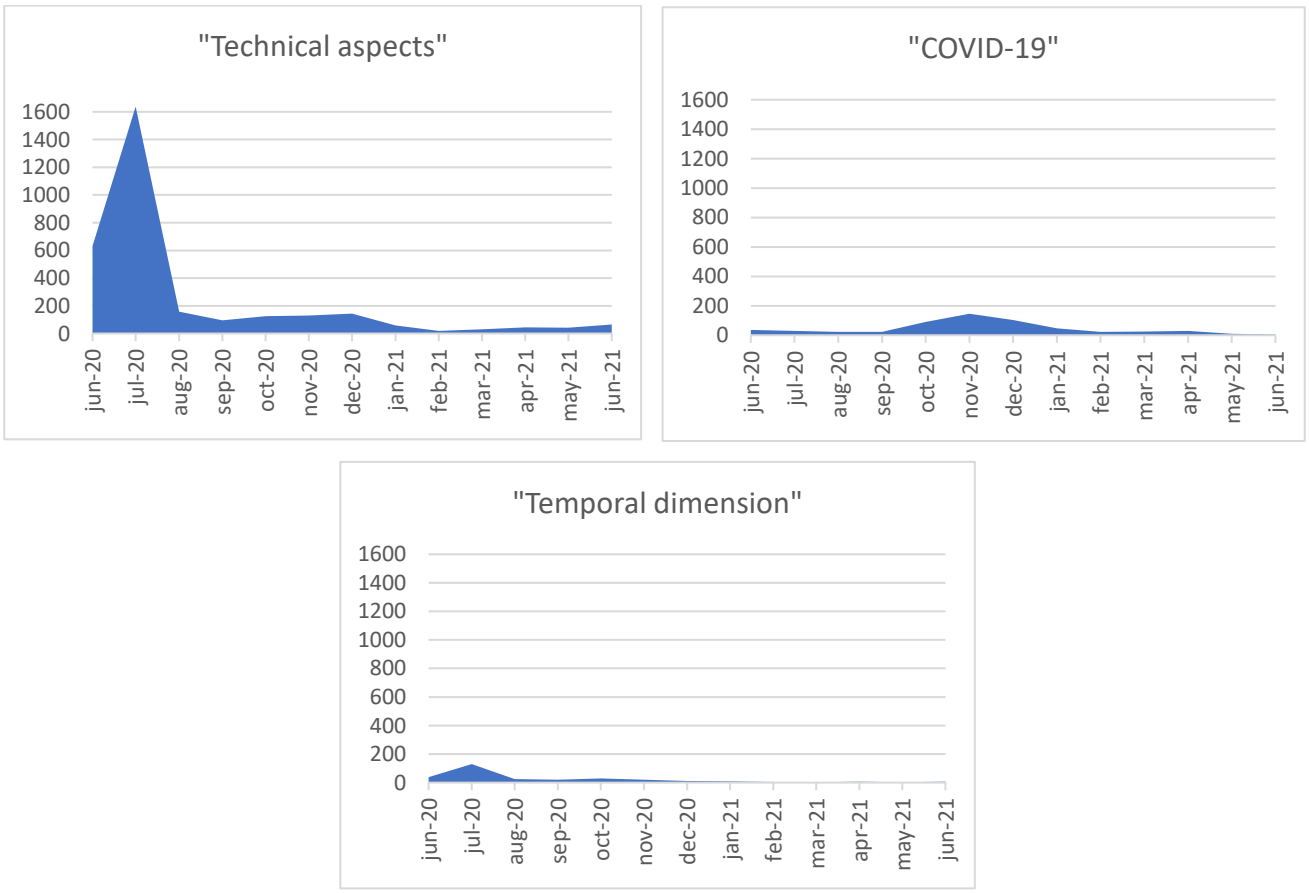


Average ratings for each category

Technical aspects	1.7
Evaluation - negative	1.1
Evaluation - positive	4.1
COVID-19	2.0
Temporal dimension	3.1

There is no point in considering how the single trigrams of the positive and negative evaluation categories, and also the "Other" ones, spread across the considered timeframe. Therefore, the following *Figure 9* pictures the other three categories, provided that with the higher numbers of "Technical aspects" the other two do not show highly significant trends with the same parameters.

Figure 9 - Number of German reviews per main trigrams category throughout months



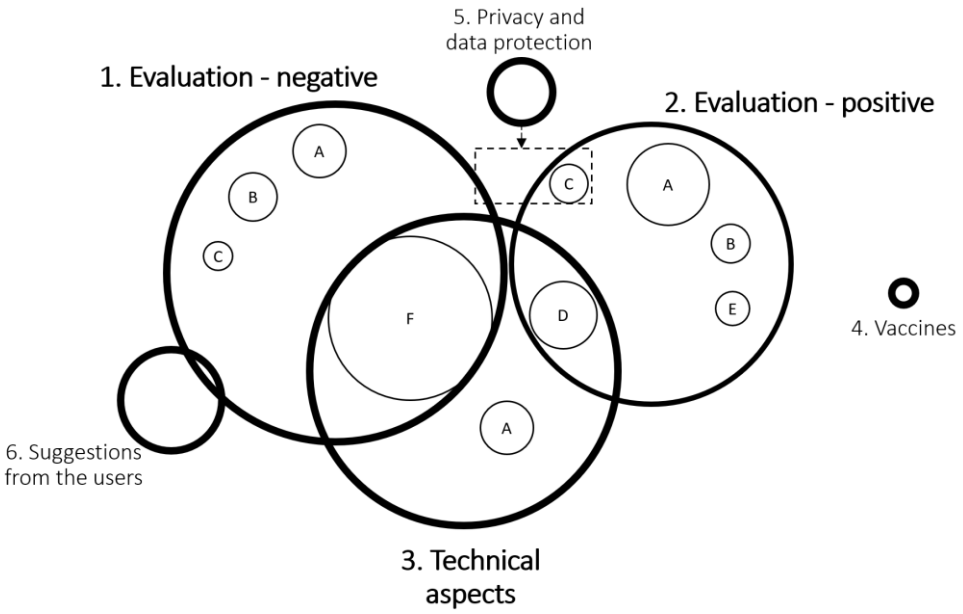
3.2.1 Interpreting the data

The "Technical aspects" category shows that most of the reviews with these trigrams were posted in the first two months of use. This result is not surprising when compared to the numbers presented at the beginning of the section. In June 2020, many users downloaded the app, and after having used it for some weeks, they posted reviews online mentioning some technical issues with the newest technology. A similar pattern emerges from the "Temporal dimension" category. Conversely, the "COVID-19" category registered a higher number of reviews in November 2020. Being this category related to topics more connected to having contracted the infectious disease or having met people who did, this pattern can be explained by the higher number of COVID-19 patients in that period, as pictured in *Figure 4* at the beginning of the section. Besides telling a little bit more about some of the trends that emerged from the previous descriptive analysis, the most recurrent trigrams offer some suggestions on the topics that most largely interested the users. To more properly understand how users tackled some of these topics, the thematic analysis is required.

3.3 Zooming in even more: thematic analysis of most liked German reviews

The thematic analysis of the 100 most-liked reviews resulted in a series of themes and sub-elements, which have been pictured in *Figure 10* showing how they relate to one another.

Figure 10 - Map of themes and elements in German reviews



1 Evaluation - negative	2 Evaluation - positive	3 Technical aspects	4 Personal responsibility
1 A Useless app	2 A Easy to use	3 A Camera and position permissions	5 Privacy and data protection
1 B Test	2 B Benefits in managing the pandemic	*D Good technical features*	6 Suggestions from the users
1 C Economic impact of the operation	2 C Data protection	*F Errors & bugs*	7 Vaccine
F Errors & bugs	2 E Good idea behind		
	D Good technical features		

3.3.1 The "Evaluation - negative" theme

As for the two previous chapters, the most recurrent theme is "Evaluation - negative". Users shared their experiences with some bugs and errors emerging when using the app (group F). These issues were strictly related to the technical dimensions of the app, especially with new updates, while other reviews covered issues related to the signaling procedure of risky encounters.

> *Despite new installation, error 3 message constantly. Uninstalled it for the last time. And that's how it stays. Just takes up memory. Sometimes it's (10), sometimes (39508) This app ran without errors for a while. I've been getting error messages for weeks. Even though it's active, it tells me to activate the app.*
>
> Posted on 17/09/2020, 1 star

> *I tested positive and also received and shared the result via the app. In the days before that, my cell phone was active (BT, WiFi, locations) next to my girlfriend's for HOURS. However, this did not receive any red warning message. It can't be, can it?*
>
> Posted on 06/11/2020, 1 star

> *After 2 weeks of always the same error messages, since today the app has reported \"Risk assessment not active\". Switching on the risk determination, however, remains unsuccessful. 2. Problem still exists 3. After update 22.07. problem still exists!!!!! 4. Google Play services up to date, problem persists!!! Version 20.26.14.*
>
> Posted on 22/07/2020, 1 star

In expressing their negative opinion on the app, users stressed how the implemented technology is useless, even if, in some cases, people recognized that the ideas that brought to its development were good.

> *The idea is actually good, but the app itself doesn't work most of the time. So it's more or less junk in my opinion.*
>
> Posted on 15/10/2020, 1 star

Another relevant element that characterized the opinion of users rating the app badly is connected to problems with the testing procedure. Several users reported that the app could not manage properly the test results.

> *I recently had to take a test and scanned the QR code right after the test. In the meantime, I have had the test result from the laboratory for almost 3 days. The app still shows me that there is no result. How should the app warn other users if the test results are not transmitted in a timely manner?*
>
> Posted on 07/11/2020, 1 star

> *Did a PCR test yesterday and got a QR code for the app. Scanned the code and waited. Always get the message that the result is not yet available. But my family doctor already has it. This time lag renders the app unusable.*
>
> Posted on 26/05/2021, 1 star

Among those who valued the app negatively, some users also stressed the economic dimension of the operation, saying that, based on their bad experience with the app, its development was a waste of public funding.

> *Are you serious? We've paid millions for the app and you can't even manage to get decent error messages? That's embarrassing.*
>
> Posted on 08/08/2020, 1 star

> *if you could give 0 stars, I would. Above all, this app is one thing: a waste of tax revenue. Sorry, that doesn't work at all. So just as little as the app itself.*
>
> Posted on 02/08/2020, 1 star

3.3.2 The "Technical aspects" theme

The second most recurrent theme is "Technical aspects". As the circle identified with the letter F shows in *Figure 10*, most of the elements are shared with the previous theme. Similarly, an additional relevant element, namely the "good technical features" element (group D), is shared with another theme. Users praised some positive technical features of the app, largely reacting to other reviews that reported bad experiences with it. Users express positive opinions on how the app performed from a technical point of view, stressing also the added value of new updates.

> *Clearly designed, quickly installed and so far no really noticeable increase in battery consumption. It's nice that the development was made transparent, but of course you can't guarantee that the latest version on GitHub corresponds to the PlayStore.*
>
> Posted on 16/06/2020, 5 stars

> *Further improvements have significantly increased the utility. So there is now a simple way to keep a contact diary and now the current numbers and trends directly in the app.*
>
> Posted on 01/02/2021, 4 stars

The only relevant element which fell just under the technical aspects theme is related to reviews about the GPS and the phone cam.

> *Bluetooth has to be activated, I know that. But when you turn off the GPS, you get a message that the app doesn't work that way. The lip service that only Bluetooth would be used is obsolete. GPS drains a lot of battery and I always turn it off as I don't want other apps using my location. If the GPS really needs to be switched on, I will unfortunately uninstall the app again.*
>
> Posted on 17/06/2020, 4 stars

> *time to all who hie r yelling about \"camera permissions\" and \"GPS location permissions\". The latter is simply not true. Don't know what kind of cell phone you have, but... The former is on my list, so it can potentially be activated, but it's currently deactivated. For what? A bit of intelligence helps: If you test*

positive, you get a QR code from the laboratory to enter the result in the app. How do you scan a QR code? Right. So calm down if you don't have a clue.

Posted on 16/06/2020, 5 stars

3.3.3 The "Evaluation - positive" theme

With respect to the positive evaluation of the app expressed in most-liked reviews, some users stressed how the app is easy to use, mainly thanks to its interface.

Very good app so far, the interface is kept simple, which is also an advantage because it doesn't overload anyone that much.

Posted on 18/06/2020, 4 stars

The UI is simple and everything is well explained.

Posted on 22/06/2020, 5 stars

Furthermore, users expressed opinions on how the large use of the CWA could help tackle the pandemic and get back to regular life.

It's so easy, the better the Corona situation can be controlled with masks and this app, the sooner we'll all have our normal lives back and keep our jobs.

Posted on 16/06/2020, 5 stars

Thanks for the Corona app. Of course I installed it and I hope that as many people as possible do so. In this way we can all make a contribution together, to our own safety.

Posted on 16/06/2020, 5 stars

Moreover, the data protection features of the app and the transparency of the whole process were praised by other users.

The app seems to work for me. Menu navigation and operation are really flawless and intuitive. The matter of data protection couldn't have been done better.

Posted on 16/06/2020, 5 stars

Super app, very simply and understandably structured. Data protection is observed and full transparency was shown here right from the start.

Posted on 17/06/2020, 5 stars

3.3.4 Other minor themes

Besides the just analyzed three main themes, it is interesting to focus on additional ones. The "Suggestions from the users" theme shows how several users engaged in proposing new features to the app. From the previous sections of this chapter, emerged how the development team of the CWA largely relied on this kind of feedback to further develop the app's functionalities. Interestingly, users suggested updates not just right after the release of the app, but across the whole analyzed period.

What might have been good, but that would only be the icing on the cake if the app has a function where you can see the current figures for Germany, like the RKI dashboard just in the app so you can see at a glance can see: What is my risk and what is the situation in my country/state/county? Would be a good addition.

Posted on 18/06/2020, 4 stars

It would be interesting to know how many contacts (positive/negative) the app registers. Just 2 numbers - last 7 days and current day. Should be an easy one as the bowls swapped via BT are stored on the device or in the app. Without such feedback, I have no sense of what the app will bring me. Maybe something like that can be done.

Posted on 22/06/2020, 3 stars

You should install a tab in the app in which the currently valid measures/rules for the region in which you are be displayed moving. That would probably be a very big incentive for many to use the app at all.

Posted on 15/03/2021, 2 stars

With respect to the "Privacy and data protection" theme, some additional findings emerge from the already considered dimensions in the positive evaluation theme. As the two reported reviews show, some users expressed strong concerns about the surveillance purposes of the app, while others stressed the positive features with respect to data protection. This last element is largely more present in the analyzed corpus of reviews with respect to the former one. Anyway, as the circle in *Figure 10* shows, data protection was not a largely discussed topic among the most-liked reviews.

The only purpose of the program is that many authorities (police, public order office, etc.) use it to determine , where the users are at the moment and monitor, for example, whether they are complying with the curfew and with whom and with how many people they are meeting - and all at the expense of the user!I strongly advise against using the program.

Posted on 10/06/2021, 1 star

to the conspiracy theorists: It's best to throw away your smartphones right away, Google, Apple, Samsung, Huawei & Co. are guaranteed to collect more data than the RKI without your knowledge.

Posted on 16/06/2020, 5 stars

Like the French case, some users engaged in commenting on the new vaccines-related functionality of the app, also saying that it was the main reason why they downloaded the app.

I installed the program (version 2.3.2) solely because it says you can save and open the digital vaccination card there.

Posted on 10/06/2021, 1 star

Where can you enter the vaccination done? I have been vaccinated for the second time since April 29th, 2021 and would like to store this in the app.

Posted on 03/05/2021, 3 stars

3.3.5 Interpreting the data

The analysis of the most-liked reviews of the CWA shows a quite strong dominance of technical-related topics. As *Figure 10* shows, technicalities are a theme on their own, but they are also among the main elements in other themes.

When not complaining about errors and bugs, users reported problems with the testing procedure, suggesting how some issues with the CWA emerged also with the non-digital and technical elements of the designed tracing procedure. However, the weight of these non-technical negative elements seems way less impactful compared to the one reported by Italian users of the Immuni app.

More strictly related to the technical aspects theme, unlike the previous two chapters, the impact of the app on the battery of the phone was not largely stressed. Conversely, like in the Italian case, users expressed their opinions on the use of GPS, showing in some cases a good knowledge of the app's functioning. Arguably, the most interesting finding from the manual analysis of German reviews comes from the theme of the suggestions from the users. Several most-liked reviews engaged in offering contributions to improve the app. From the interviews previously analyzed emerges that these suggestions were often screened and, whether valuable, included in further updates of the app. Such an approach may have contributed to bringing the CWA closer to its users since it was an evolving tool that was periodically re-shaped also on users' expressed opinions and needs.

Just like the French case, it is interesting to notice how the functionalities related to vaccines, despite being introduced toward the end of the considered period, were part of the discussed topics in the most-liked reviews. This element could show how non-DCT-related functionalities of the app were largely considered by the users as well.

Conversely, with respect to more DCT-related elements, the debate on transparency and data protection, one of the main issues in the design and implementation phase, does not seem to interest users that much. Some reviews expressed approval of the data protection strategies that the app had, but these discussions were far to be among the most represented ones. Another issue that largely characterized the early phase of the app design, namely the debate on the centralized and decentralized approach, received even less attention from the users. They do not seem to care about the role of Apple and Google in this debate. Instead, users do care, as the analysis of the trigrams shows, about the role of Google with respect to more practical issues related to the app's functioning.

3.4 A further consideration on the use of the German CTA: the role of local healthcare authorities

The gathered empirical materials offer the chance to elaborate a little bit more on a topic that was discussed in the previous two chapters as well, namely the role of local healthcare authorities. It has been stressed how, in the Italian DCT strategy, the local healthcare authorities played a pivotal role after the app's rollout, also because the designed DCT procedure largely relied on them. Conversely, in France, they were not significantly involved in the use of the app because most of the procedure was controlled and managed by central authorities. Germany followed a similar path to the French one. As the interviewee from the RKI precisely describes, German local healthcare authorities were not largely involved in the DCT procedure, for two main reasons. First of all, time constraints and the pressure from the pandemic did not allow the involvement of the many German healthcare authorities in the design phase, and therefore the tracing solution was developed without them, as by the way happened also in Italy and France. Then, also because the local authorities did not participate in the design, the whole process was structured in order to avoid introducing additional tasks for them, which were already under high pressure from the many other needs and requirements introduced with the pandemic.

> *The CWA, unlike in other countries is not directly linked to the health authorities. This is due to the fact that we didn't want to, it's a bit difficult... On the one hand, they didn't... we had just this very short development phase and it was hard to include all 450 counties, and their ideas and visions. So, we decided to build, more or less, different from them, because in Germany the laboratories are quite strong: people get tested and get the results from the laboratory and we decided to implement them. So, if people get tested, they would get from the laboratory the test result into the CWA. And most people, during the high peaks of the CWA, which we also found in the data, didn't call the healthcare authorities, because there were long waiting times on the hotline. They rather did go to their general practitioner to get tested there. So, it was seen critically in the beginning, but... I am also quite often in discussion with several health authorities in Germany... but it led to a big help, because people that got warn by the CWA didn't need to be an additional [burden] to them, because they contacted their GP, and that helped to save sources and focus on other contacts.*
>
> *As you can see, RKI is the National Public Health Institute in Germany, and therefore organized by the Federal Health Ministry. This CWA was kind of a digital tool, it was an add on I would say, it was not directly linked to the county level. Does make any sense?*
>
> *I think that, by not focusing too much on the healthcare authorities in Germany, we got really relief as I already said. German GPs are really strong, and they also are connected to laboratories and people can get tested. It was really a pain in the ass getting all the laboratories to participate, because there is also a big degree of freedom, and I guess in Germany there are over 400 laboratories who did test on Corona. By building some kind of next to the health authorities, the local health authorities, some kind of technology, we were really able to be a relief for them and detect infection chains to further develop it.*
>
> RKI

4. CoronaWarnApp's design, implementation, and use wrap up

This chapter has described and analyzed the development of the German DCT strategy through the construction of the CWA, focusing on its design, implementation, and use.

With respect to the design, the German strategy was significantly influenced by the debates happening at the EU level on the different technical protocols. This should not surprise the reader since many German actors, RKI included, largely participated in the early EU debates on DCT. The German approach to DCT, which started as centralized, between March and April 2020, switched to decentralized, under the decision of the Health Ministry, which from that point onwards strongly guided the CTA development with its most important institute, the RKI. To keep working on the design of the app and carry out its implementation, the German Government contracted two companies, namely SAP and Deutsche Telekom. This new group of actors collaborated on the development of the app following the principles of transparency through open-source software, data protection, and personal freedom. As happened for most of the CTAs based on the decentralized approach, the technical implementation was smoother because of the use of Apple and Google's ENF, which managed the lower level of the app's implementation. Furthermore, local healthcare authorities were not involved in the designed process of DCT through the CTA.

What clearly emerged from the interviewees is that the design and implementation process of the app did not finish with the release on June 16th, 2020. The German Government extended the contract with SAP and Deutsche Telekom to further update the app and add new features. All the actors involved in the development of the app monitored the feedback from the users, the developers' community, and other stakeholders to further improve it with new characteristics. Ultimately, as months passed by, the CWA that was initially designed just as a DCT tool became a more comprehensive hub where information on COVID-19 was available, swaps could be required, and modules and documentation could be downloaded, similarly to the new version of the French app.

Users largely seem to have largely appreciated the app at the launch: many downloads happened in the first two months, and several reviews were posted with many 5-star ratings. Then, throughout the considered period, the number of 1-star reviews raised to the point that the share of the highest and lowest rate was almost equal. The automatic analysis of most recurring trigrams among the almost seventy thousand scraped reviews showed that users mainly talked about technology-related issues. This finding is confirmed also by the manual thematic analysis. What it is interesting to stress once again is that many reviews, also compared to the two previously analyzed cases, engaged in suggesting new updates and new features for the app. So, the strategy of the actors involved in the design and implementation found a proper response in the way several users approached the app reviewing process. This users' behavior was also arguably fostered by the fact that the RKI sometimes replied to the posted reviews, explaining design choices, and thanking for suggestions.

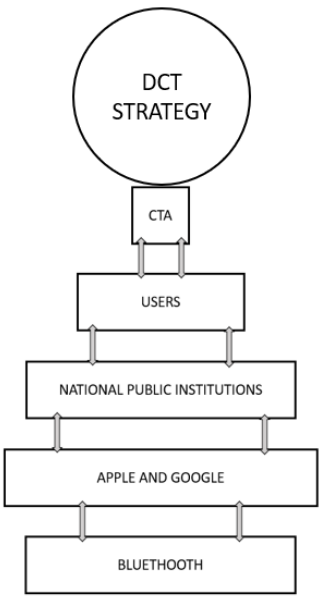
4.1 Succinctly picturing the German DCT strategy

Relying on the analysis presented so far to try to picture the German DCT strategy deployment, unlike the previous two chapters, no major problems seem to emerge in the relationships between different actors. The fact that the leadership of the whole strategy was on the healthcare side of the Government, instead that on the digital one like in Italy and France, arguably contributed to developing also a proper organizational infrastructure around the released CTA. A significant part of this smoother relationship between public institutions and users should be related to the fact that local healthcare authorities were not asked to participate in the digital tracing procedure, unlike what happened in Italy. Of course, as the analysis of reviews showed, some issues emerged as well when dealing with test results from laboratories, but the impact of these issues did not seem to jeopardize the whole strategy.

The previous pages described how several users expressed negative evaluations of the app, however, the relationship between them and the technological artifact was never badly compromised: the higher number of downloads proves that. Furthermore, it is relevant to stress that the continuous update of the CTA by the German developers tried to incorporate suggestions from the users to make the technology more in line with their needs. Therefore, many months after its release, the app was very different with respect to its first version. After many updates, the contact tracing functionalities were just part of the many features that made the CWA more similar to the French TousAntiCovid than the Italian Immuni.

As for the previous two chapters, *Figure 11* pictures in a succinct way the relationships between relevant actors and actants. Unlike Italy and France, no major issues compromised the necessary equilibrium to properly carry out a DCT strategy in Germany, as by the way stressed also by several interviews excerpts previously reported.

Figure 11 - Different actors and actant that contributed to the deployment of the German DCT strategy

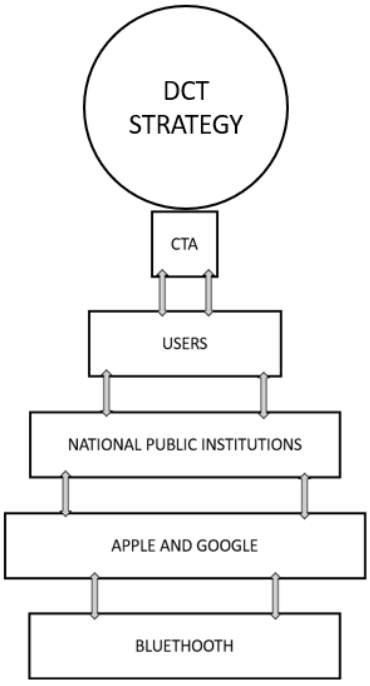


With this chapter on the German DCT strategy, the analysis of the three selected cases comes to an end. Several findings have been presented in this chapter and the previous two. Some initial links between the three different cases have been already traced. However, the following chapter will engage in a more structured comparison of the aggregated dimensions emerging from each case, and it will try to relate what emerged from the study of the development of DCT strategies in the three countries with the theoretical suggestions presented in the early pages of this work.

Chapter 8 – Discussing findings and connecting them to the literature

To discuss the main findings of this work, it is important to recall the two research questions that guided all the inquiry: what influenced the design and implementation of digital contact tracing strategies during the COVID-19 pandemic in Europe? Why did digital contact tracing result in a marginal non-pharmaceutical intervention in the fight against COVID-19? The elements that could provide answers to both questions have been attentively presented throughout previous pages. This chapter aims to gather them more concisely and relate them to one another, also stressing the comparative dimension between different cases. Once again, a valuable initial guiding principle is "follow the actor" which would help organize the discussion and introduce additional concepts related to more general dimensions covered in the early pages of the work. That is why the scheme that supported the final remarks of the analysis of each case study, namely the one pictured in *Figure 1*, works as a valuable reference to organize the present discussion as well. Focusing on Bluetooth, Apple and Google, the national public institutions, the users, and the CTAs would help answer the two research questions from a comprehensive point of view and relate the findings to the theoretical dimensions that characterized this contribution.

Figure 1 – Different actors and actant that contributed to the deployment of the DCT strategy



1. Bluetooth: the importance of technical elements in policy implementation through digital technologies

As also pictured in *Figure 1*, Bluetooth is the lowest level of the set of main actors and actants on which the DCT lays on. It could be proper to interpret this "low level" also in informatics terms, namely the technological infrastructure, that is the set of digital elements that makes an application work. Bluetooth is exactly that: the main technical element through which run a DCT strategy deployed through smartphone apps. In chapter four, it has been stressed that Bluetooth technology was not invented for measurement purposes, but for communication ones, such as connecting different devices (Jacob & Lawarée, 2021). With respect to DCT through CTAs, the smartphones' Bluetooth was used to measure the time of exposure and the distance between devices (Ferretti et al., 2020). The way Bluetooth was initially designed, which defined its communication affordances better than its measuring ones (Akrich & Latour, 1992; Bucher & Helmond, 2018), arguably played a role in the proper deployment of the DCT strategy. As already mentioned in the early pages of this contribution, experiments conducted on public transportation have shown how the reliability of Bluetooth for measuring purposes was quite low. Scholars argued that "in the tram there is little correlation between received signal strength and distance between handsets. Similar ranges of signal strength are observed both between handsets which are less than 2m apart and handsets which are greater than 2m apart (including when handsets are up to 5m apart). This is likely due to reflections from the metal walls, floor and ceiling within the tram, metal being known to be a strong reflector of radio signals, and is coherent with the behaviour observed on a commuter bus" (Leith & Farrell, 2020a, p. 6).

The actor-network theory clearly states the agency of non-human actants (Akrich & Latour, 1992); with respect to the analyzed issue, the role that an unanimated technology played in the deployment of a digital tracing strategy needs to be attentively considered. Of course, this work could not provide technical evidence of Bluetooth problems when tracing contacts through CTAs. However, also from a theoretical point of view, it is interesting to notice how the implementation of a policy, through digital technologies, is strictly bounded by the affordances of systems and technologies available at a certain moment. A policy that needs to rely on digital technologies has to face the technical characteristics of the selected tool that could ultimately impact its deployment and its success.

As argued in previous pages, Bluetooth was the best available option to carry out tracing on a large scale, GPS or other hardware solutions had way more complications. Being the best solution available does not mean being the best solution overall. Due to weaknesses and problems in repurposing Bluetooth from a communication to a measurement technology, the whole DCT strategy already experienced some significant issues in the lowest level of actants that contributed to its deployment. With respect to Bluetooth, smartphone operating systems play a crucial role in establishing additional non-technical affordances of this

technology. For this reason, Apple and Google had a large impact on Bluetooth regulating policies which ultimately influenced the whole DCT design and implementation process.

2. Apple & Google: the primacy through the control of the technical infrastructure

The development of all three analyzed national CTAs largely depended on the role of Apple and Google. Chapter four attentively described how the two tech firms participated in DCT. The main issue concerning Apple and Google's involvement is arguably related to Apple's Bluetooth policy, which does not allow apps to access Bluetooth when in the background because of data protection reasons (Hern, 2020). The two firms partnered together and released the Exposure Notification Network, a framework largely inspired by DP-3T decentralized protocol. The ENF became the only official way Apple "opened up" Bluetooth communication with its devices, establishing some clear privacy and data protection principles that needed to be followed by those who wanted to rely on the ENF.

Experts who participated in the development of the Italian and German apps explained how big of an impact the announcement of the two US firms had. With respect to Italy, the members of the task force had to reconsider their evaluation of the different DCT solutions proposed to the Government's call right after the announcement by Apple and Google. Most of the task force members considered the ENF the "game changer" in the development process of a DCT app. Similarly, in Germany, both the representative of the RKI, which managed the project from the public institution side, and the employees from SAP, which was involved in the technical implementation, stressed that Apple and Google, through the ENF, played a big part in defining the CTA's characteristics.

France is one of the few countries in Europe that did not rely on Apple and Google's solution. Despite not relying on the ENF, the impact of the two tech firms was arguably even higher in the development of the French DCT strategy. First of all, the technical team that engaged in developing the CTA for France struggled to find a workaround to make DCT work even without Apple unlocking the Bluetooth communication of its devices. Ultimately, they found a technical suboptimal solution that granted them to get in touch with iPhones, but arguably not as precisely as the ENF (Inria, 2020a). Then, the involvement of the two US firms was largely discussed among the national political decision-makers, who finally opted to develop an autonomous DCT solution. The debate largely pivoted around the concept of digital sovereignty, stressing that the involvement of two private firms in publicly relevant issues, such as healthcare, strongly limited and threatened the State's autonomy.

Of course, this work does not aim at expressing value statements on whether following the ENF was actually a limitation of national digital sovereignty, or rather a useful tool for States that just supported their strategy following similar principles. Conversely, what it is interesting to stress, getting back to some of the concepts introduced in chapter two, are the suggestions that emerge from the analyzed phenomena with respect to technology governance and the role of platforms as infrastructure.

Taking into account the “arrangements of power” (DeNardis, 2012), namely the influence that different actors had in shaping the development of technology, it could be fairly convincingly argued that Apple and Google played the largest role in the construction of CTAs.

As the OECD puts it, "technology governance can be defined as the process of exercising political, economic and administrative authority in the development, diffusion and operation of technology in societies. It can consist of norms (e.g. regulations, standards, and customs), but can also be operationalized through physical and virtual architectures that manage risks and benefits" (OECD, 2019). The analysis carried out in this work shows that the early governance of the DCT strategy was largely on Apple and Google who set the features of the ENF based on their priorities and values, especially with respect to data protection and privacy. France showed that another solution was available, however at quite high costs: not having a DCT protocol perfectly working on iPhones, but most importantly not having a CTA interoperable with most of the other EU CTAs. The exclusion of France from the larger group of EU countries relying on the ENF happened also because the two firms worked like a sort of infrastructure. By controlling almost all the smartphones' operating systems, Apple and Google could easily create a network of intercommunicating apps, from which those that did not employ their framework were excluded. This evidence resonates with additional concepts introduced in chapter two. Authors have shown how contemporary digital platforms have become gatekeepers of several online and digital ecosystems, where their own set of rules and guiding principles are applied (Gillespie, 2017; van Dijck et al., 2019). As others have argued, public institutions nowadays find themselves relying on digital platforms services and infrastructures (Greene, 2018; van Dijk et al., 2018). On the one hand, tech firms are the "intermediaries providing citizens with access to the digital public sphere" (DeNardis & Hackl, 2015, p. 769). On the other, they are gatekeepers of the innovations that happen on their platforms (*ibidem*). Furthermore, these features of tech firms made them extend their influence beyond the markets in which they initially started operating and reach the whole society (van Dijck et al., 2019; Van Dijck, 2020). That is exactly what happened with the development of a DCT strategy. Apple and Google, two tech firms, had a better working, faster-to-implement, and easier-to-manage tracing protocol, useful for healthcare purposes. As gatekeepers of the smartphone ecosystem, they set clear ethical principles and rules to deploy the public DCT strategy. With respect to this specific case, as many interviewees argued, Apple and Google's principles were quite in line with those expressed by many scholars involved in the field. But, what if, in future deployments of policies through digital technologies, most of the values and principles of private actors controlling the digital ecosystem and the ones of public institutions would not match? That is what, by the way, happened in France.

Unlike other contributions reflecting on DCT during COVID-19 that suggested a power-sharing dynamic between national and supra-national public institutions and Apple and Google (Lazing et al., 2022), this work clearly states the primacy of the latter actors. The findings of this research have shown that the two tech firms were the real "game changer" in the design and implementation process. It is also really interesting to

notice that, during the pandemic time, National Governments were able to set quite restrictive rules on the population, such as curfews, lockdowns, and several other closings. However, National Governments, as the analyzed case of the French CTA clearly shows, were not able to bend big tech firms toward their will.
From the analysis of DCT development in Europe, some evidence on the power arrangements with respect to digital technologies emerges, of course, it is a matter that needs to be further explored since it incorporates many relevant issues even for future policy implementations through digital technologies.

3. National public institutions: different involved actors lead to different results and different employment of digital technologies

The approach by national public institutions to the issue of interest was quite different in the three analyzed cases, from the point of view of the selection process of the CTA solution, the most relevant issues discussed, and the leadership of the project.
As chapter five showed, in Italy, most of the work in the early development of a national DCT strategy was carried out under the control of the Innovation Ministry. The Ministry identified external consultants who were charged with the task of identifying the best DCT solution that answered a government's fast call. Both the experts involved in the selection process and the Innovation Ministry largely stressed the importance of privacy and data protection when identifying an early DCT solution to be further developed to give Italy its national CTA. Furthermore, as extensively covered in the chapter on the Italian case, the later organizational infrastructure designed for DCT largely relied on local healthcare authorities, which were already overwhelmed by the manual contact tracing procedures and could not keep up with the additional task of DCT. The local healthcare authorities interviewed for this research explained how the Immuni app played no role in their strategy against COVID-19, which started relying on different digital tools.

France followed a different path since the beginning because a national public research center was identified as the main responsible for developing a national contact tracing app. As already stressed in the previous section, the work that was required to the research institute Inria was quite challenging because the Bluetooth protocol was to be designed as well. Just like in Italy, the leadership of the whole project was on the Secretary of State in charge of the digital. However, the main discussed topics and issues were quite different with respect to Italy since the French public institutions largely debated on the issue of digital sovereignty, as stressed in the previous section as well. Moreover, the role of local healthcare authorities was different, since the planned contact tracing strategies did not mainly rely on them.

Similarly, Germany was able to develop a DCT strategy that was not relying on local healthcare authorities. Even if Germany has a healthcare system that is largely based on local authorities, as in Italy, it was decided to manage DCT through the CTA at the central level, avoiding putting additional pressure on the local healthcare authorities that were already in charge of the manual contact tracing.

Unlike the two previously analyzed cases, Germany managed the whole DCT strategy mainly through its Health Ministry via the Robert Koch Institute. No main discussed issues could be clearly identified during the development process of the CoronaWarnApp at the institutional level. However, it could be underlined how, since at the beginning Germany was following the centralized approach to DCT and then changed to the decentralized one mainly for transparency and security reasons, these two issues were quite strongly addressed by national public institutions.

As a further example of the different trajectories that DCT through CTAs had in each country, it could be interesting to mention the different isolation policies when a person tested positive. As *Figure 2* in Chapters 5, 6, and 7 showed, the rules slightly changed from country to country. When the app was first released, a person who tested positive in Italy needed to be isolated for 10 days and then repeat the test, having at least 3 days with no symptoms. On the other hand, in France, a positive person needed to isolate for 7 days, while in Germany for 10, and get back to regular life having at least 2 days with no symptoms.
As the DCT strategy was not coherent between Italy, France, and Germany with respect to one of the final steps, namely isolation policies, it was not coherent even in its early steps, namely its design and implementation.

On the one hand, as previously summarized, Italy sought solutions and initial support outside the public institutions. First of all, a fast call for DCT technologies was released in order to gather ideas from civil society and the private sector. Furthermore, even the evaluation of these solutions was assigned to consultants that were grouped in a newly established task force. On the other hand, both France and Germany could count on a national public institute that managed the whole process.
With respect to the Italian case, having actors that normally operate outside the public institutions largely guiding the definition process of DCT contributed to narrowing the focus on the app itself, lacking a broader view of the larger scenario. Conversely, in the French and German cases, the involvement of two public institutes, which in general should be more used to larger national projects with respect to an external consultant, contributed to having a more comprehensive approach to DCT development. Eventually, having a broader view of the whole scenario instead than a very specific one on the digital artifact prevented some of the early problems happing in Italy from manifesting also in Germany and France, such as the poor integration with local healthcare authorities.
Moreover, as the STS literature suggests, technical and scientific knowledge largely relies on the skills, competencies, and values of the actors involved (Collins, 1983; Hackett et al., 2008; Knorr-Cetina, 1983). Therefore, the different public institutional actors involved in the three different countries contributed to influencing the final technological not only based on their broad or narrow approach to the issue, but also with respect to their competencies and values. In Italy, the leadership of the Innovation Ministry led to a large focus on the digital dimension of the DCT strategy, especially with respect to privacy and data

protection, leaving the organizational one behind, which created the well-documented issues with local healthcare authorities. Conversely, Germany with the leadership of the RKI was able to structure more properly not only the technological side of the DCT strategy but also its organizational one, which ultimately brought it to experience fewer problems in its deployment. Finally, France, with its national decision-makers largely insisting on a sovereign solution, decided to develop its CTA without relying on Apple and Google's framework and experiencing all the issues that have been already stressed several times with respect to the technological infrastructure.

In general, the analysis of DCT development in Italy, France, and Germany suggests how, when designing a public intervention through digital technology, the digital technology itself should not be the only focus. The proper performance of digital technology is granted when the organizational infrastructure around it is designed accordingly. The Italian case, in which the different processes and actors that were supposed to support the use of the app were not properly structured, works as an example. Even if the digital technology is working per se, the implementation of the policy through it may experience problems from other contextual dimensions and actors not properly controlled and fine-tuned.

3.1 An open question: why that happened?

If the empirical inquiry gave the chance to identify the different trajectories that each country followed to develop a national DCT solution and how these trajectories impacted DCT deployment, why Italy decided to refer to external consultants, while France and Germany to national institutes, it is not clearly explainable with the available materials. Nevertheless, acknowledging and making this "why question" explicit is somehow important. The interviews with relevant actors realized for this work would have been a proper tool to try to understand a little bit more about this question. However, the precise trajectories of DCT development in Italy, France, and Germany emerged from the comprehensive analysis of all the materials, when the empirical field was already closed. Therefore, without having the chance to count on empirical materials on this issue, this "why question" could be here addressed just with some general reflections, speculations, and hypotheses that for sure would need further research. One of the reasons that brought the Italian Innovation Ministry to seek outside help with respect to the design and implementation of a DCT strategy could be identified in the fact that no institute like the French Inria or the German RKI exists in Italy. Furthermore, it should be noted that the new Italian Government – named Conte II -, and therefore the newly established Innovation Ministry, started just six months before the beginning of the pandemic (Governo Italiano, n.d.). It is reasonable to think that a proper internal structure able to manage autonomously the DCT development was not available by March 2020.

Concerning the fact that the leadership of DCT development in Italy and France was attributed to the Innovation Ministries, while in Germany to the Healthcare one, the available knowledge emerging from this work does not suggest reasonable explanations to share. As it has been shown, the different leaders in the

project largely influenced the whole DCT development, therefore this is a further dimension that could be explored.

4. The users: different perspectives between countries, but the common feature of having divergent priorities with respect to designers

In the three previous chapters, a description of users' perspectives and opinions on the CTAs has been provided through different metrics. Starting from the ratings that users attributed to the apps, Italy places third with 2.3 stars average ratings, followed by France with 2.6, and then Germany with 2.9. The distribution of 1-star or 5-star ratings is quite similar between the three analyzed countries, however, Italy and Germany largely registered higher ratings right after the release of their app, while France towards the end of the considered period, arguably due to the new features introduced with TousAntiCovid.

The trigrams analysis of all the scraped reviews shows a large dominance of elements related to technical aspects, followed by elements related to the evaluation of the app, which was mainly negative in Italy, while positive in Germany, but even more largely in France.

Besides these descriptive metrics, the most informative findings come from the thematic analysis. As the trigrams suggested, positive and negative evaluations of the app were largely present in each of the three cases, intersecting with elements related to the technicalities of the implemented CTA. Focusing on specific elements of the three cases, German users engage in suggesting updates to the apps more than the users of the other two countries. Conversely, French users largely stressed the useful updates of the TousAntiCovid app with respect to features not related to DCT, such as news updates and digitization of paperwork. It is interesting to notice how both these elements are quite in line with the strategy that was followed by designers, namely constant updates of the app also based on users' feedback in Germany, and a new version of the app which is not just for tracing in France.

In general, the active users' involvement has been analyzed in STS scholarships, showing how users can modify, resist, and reconfigure technologies (Oudshoorn & Pinch, 2003). Furthermore, ANT scholars explored how sometimes users can engage with technologies in specific ways that were not initially inscribed in them (Akrich, 1992). These elements clearly resonate with the users' relationship with CTAs in France and Germany. Through their reviews, complaints, and behaviors users made the digital tracing technology evolve from what it was originally planned.

With respect to Italy, concerning technology-related aspects, users reported fewer problems with bugs and errors compared to the other two countries. However, several users lamented issues with their phone's battery and complained that Immuni was not working on older phones. Clearly this last element, but arguably also the one related to the battery, should be related to the fact that the Italian users did not have so up-to-date devices. The fact that the country is not that technologically savvy (Pizzul, 2021) could have played a role, raising quite significant matters to tackle.

When deciding to carry out a policy through digital technologies, just like it happened with DCT through CTAs, the fact that some people could be excluded from it because they do not own proper personal devices is a pivotal issue, that, as far as the findings of this work showed, was not significantly considered during the design phase.

Always referring to Italian users' perspectives and opinions on their CTA with respect to their counterparts in France and Germany, the previous section and the dedicated chapter largely stressed how they focused on the role of the local healthcare authorities. Furthermore, the theme of privacy and data protection was more developed compared to the other countries, but it was very far from having the importance that it had for those involved in the design and implementation of the app. This characteristic can be spotted also in France's and Germany's analyses. In general, very small attention was dedicated by the users to the issues that mainly interested the design and implementation phase, namely digital sovereignty in France, and transparency and security in Germany. It is interesting to notice in all three considered cases that the expressed values, priorities, and perspectives on the CTAs are very different between the actors involved in the design and the users involved in the use phase. As already argued, those involved in the design largely influence the technology's characteristics, but users can do it too, especially if some of their opinions on the app do not match the one of the designers.

5. The contact tracing apps: applying the STS concept of boundary object and getting relevant additional insights

Chapter two described how the concepts of "boundary object" introduced by Susan Leigh Star and James R. Griesemer in 1989 relate to the STS scholarly tradition which largely influenced the present work as well. The two scholars defined boundary objects as "objects which are both plastic enough to adapt to local needs and the constraints of several parties employing them, yet robust enough to maintain a common identity across sites" (Star & Griesemer, 1989, p. 393) which can create cooperation in absence of consensus. Initially, this theoretical configuration worked as a useful concept that offered relevant guidelines to explore the role of objects (digital ones in the analyzed case). With respect to DCT, digital objects are surrounded by a network of different actors working towards a similar goal, namely fighting the pandemic, but with different means. Take for instance the perspective of healthcare authorities in Italy, eager to have data to cast prediction models of pandemic diffusion, or the data protection-oriented members of the task force.

What is interesting to notice concerning the features of the boundary object concept is that the findings of this work suggest that the CTA did not work as such in Italy. On the one hand, Immuni was very robustly defined, having specific affordances, features, and characteristics. It emerged from a context where full consensus was far to be reached, even among people involved in the early evaluation of different solutions since some of them were still convinced that the GPS could have played a role. However, the robustness was not sided by the flexibility that could make it work as a proper solution in different contexts, outside the one

where it was initially scripted. The many-time mentioned case of local healthcare authorities in Italy is a clear example. Professionals working on manual contact tracing received a tool that was not tailored to their needs. Immuni was not flexible enough to adapt to their ongoing activities and facilitate tracing procedures for local healthcare authorities. As the interviews showed, they were looking for a tool that could help them manage the daily enormous number of COVID-19 patients and related encounters, but Immuni was not planned for that. These elements add up to the organizational issues that have been previously described: Immuni's non-digital infrastructure was not properly planned, and the app was not flexible enough to adapt to it. The lack of flexibility of the Italian CTA is visible also when considering the role of the users. The technological artifact did not undergo any major features update until the introduction of the vaccine certificate towards the end of the considered period, around May-June 2021. As shown in the analysis of the Italian case, the rigidity in the scope of the app was clearly planned: Immuni was developed for DCT and that was its task. A clear stance with respect to the strategy to implement, however made the digital object not easily adaptable to groups of people who would not grasp contact tracing usefulness.

Conversely, as stressed many times, France and Germany added features and characteristics to their app, also based on users' suggestions, which often were not related to tracing functionalities. Planning the organizational infrastructure for the implementation of their DCT strategy and having an app more flexible for *re-inscribing* some of its characteristics made the TousAntiCovid app and the CoronaWarnApp way closer to boundary objects than Immuni. When defining a boundary object Star and Griesemer also explain how "they have different meanings in different social worlds but their structure is common enough to more than one world to make them recognizable, a means of translation" (Star & Griesemer, 1989, p. 393). The analysis of users' reviews has shown that some users interacted with the CTAs mainly for additional features such as statistics or news reporting. In the eyes of some users, the TouAntiCovids or the CoronaWarnApps could have just been useful tools to stay updated with the development of the pandemic, but the tracing functionalities were still there, and that is what matters for those who initially develop them with the idea of having an additional NPIs against COVID-19.

Therefore, in general, it could be argued that having a flexible technical solution in a setting with many controversies and opposing views between relevant actors is preferable to having a rigid one. Being able to develop a technological artifact that has the features of a boundary object could help overcome some of the refusals from core actors that would ultimately jeopardize the larger strategy that the artifact was supposed to deploy.

6. Why CTAs did not become a main NPI during the pandemic

Having reflected in a more structured way on the development of the DCT strategy in the three analyzed European cases, starting from the main actors involved, helps answer the second research question as well. CTAs did not become a significant NPI during the COVID-19 pandemic because the support of those who have

been identified as core actors or actants lacked at pivotal points during the DCT strategy deployment. All the previously considered actors and actants, at different moments and at different extents, contributed to making the final result different from what was planned, or hoped. Most importantly, probably with the only exception of Germany, users lacked participation in the DCT strategy. The number of downloads never reached very large numbers during the considered period. Furthermore, it is well-known that the number of downloads is not necessarily related to the number of people actually using the app, and using it for tracing purposes.

Besides users, actors in the national public institutions did not fully support the deployment of this strategy, as the final paragraphs of chapters dedicated to the case studies showed. It is the case of Italian local healthcare authorities, or the Healthcare Ministry as well, which, based on what was reported by interviewees, did not really participate in successfully carrying out the DCT strategy.

Apple and Google constituted an obstacle as well, especially with respect to the French app. Furthermore, having some EU countries, and a relevant one like France, excluded from a common DCT framework at the continental level did not help the success of an EU DCT strategy already compromised by problems in members' states and among users.

Finally, it has been shown how Bluetooth was not the best technology to carry out such kind of activity. This weakness could have also contributed to not having some encounters properly registered.

Therefore, this set of problems and weaknesses happening with the main involved actors and actants in carrying out a DCT strategy through CTAs, which have been called "shakes" in the previous chapters, made it become a marginal one compared to less technology-sophisticated ones such as masks or physical distancing while waiting for vaccine development.

The German case seems the one less influenced by the mentioned problems and presented fewer issues in the relationships between different actors, provided that lower-level difficulties with Bluetooth happened also over there. Nevertheless, a DCT strategy that worked quite well in one country cannot influence the whole European system, which experienced the problems that have been mentioned and ended up having a quite marginal role for CTAs.

Having presented the answers to the research questions in a more organized and condensed fashion, gathering the findings that were presented across the previous chapters, is finally time to head toward the conclusions of this work.

Chapter 9 – Conclusions and further implications

Entering the final chapter of this work, it could be useful to briefly recall the different steps that led up to this point. First of all, the whole research has been oriented toward the study and exploration of one of the NPIs deployed in Europe to fight the COVID-19 pandemic. The study of DCT moved from a precise theoretical background, which influenced both the ontological and epistemological stance during the whole research process. Different traditions within the broad domain of Science and Technology Studies suggested useful theoretical and methodological approaches to tackle the issue of interest. Moreover, additional streams of literature have been acknowledged in order to better locate this research within ongoing debates. Referring to the aims of the research and to the large corpus of considered contributions, two clear research questions were identified: what influenced the design and implementation of digital contact tracing strategies during the COVID-19 pandemic in Europe? Why did digital contact tracing result in a marginal non-pharmaceutical intervention in the fight against COVID-19? To answer these questions, three case studies were selected. The analysis of DCT development in Italy, France, and Germany was explored through document analysis, interviews with relevant actors, and the analysis of users' reviews. Before entering the presentation of the findings for each case, this contribution engaged with the role played by supra-national actors in the issue of interest, namely scholars participating in the definition of DCT protocols, public institutions, Apple and Google, and the non-human actant Bluetooth. There is no point summarizing once again the findings coming from the three chapters on the case studies since it has been done at the end of each of them and also in the previous chapter. Conversely, on the main topics of the previous chapter is important to insist further since they constitute the main output of this contribution. The scheme that opens chapter 8, which comes from the last paragraphs of the chapters on the three case studies, succinctly describes DCT development from how it has been understood in this contribution. The development of DCT through digital technology, namely a smartphone app, has been considered a complex interplay between human and non-human actors, that despite the look of *Figure 1* in chapter 8, is far to be stable and linear. As the concept of "shakes" in the relationships between different actors introduced throughout the work showed, the problems that were experienced between different actors in CTAs design, implementation, and use contribute to making the European DCT strategy "fall". Two of the considered countries, namely France and Germany, were able to tackle these "shakes" between the different actors and reestablish a sort of equilibrium in their strategy, without, however, registering extremely satisfying performances with respect to what was initially planned. As interviewees from Germany pointed out, the DCT strategy worked better over there, but for sure it was not able to properly influence the European one, which ultimately could not include DCT among the effective strategies against the COVID-19 pandemic.

Furthermore, chapter 8 built links between the findings of the case studies and relevant contributions analyzed throughout the work. It has been shown how the analysis of DCT development makes the importance of non-human actors explicit and confirms the primary role of tech corporations when engaging with digital technologies. Then, a distinction between the users' and the designers' perspectives has been presented. Finally, the concept of boundary object is applied to the issue of interest, suggesting some further steps. However, this contribution could make a step further and see how some of these elements could contribute to the broader social science knowledge, especially with respect to digital platforms, privacy, the interplay between the healthcare and digital domain, and ultimately the STS framework used for this research.

1. Zooming out to amplify the view: theory implications

It has been argued that, for theorizing purposes, the "here-and-now" needs to be connected to the "elsewhere-and-then" through a zooming out from the object of study, in order to put it in "larger configurations" (Nicolini, 2009). Therefore, zooming out needs to be a further step with respect to the very case-specific research aims that guided this work.

In general, it must be acknowledged that one of the characteristics of the theoretical toolkit defined for this contribution is the high adherence to the object of study. Therefore, on the one hand, this toolkit properly helps describe and understand the construction of relevant technologies, through a clear epistemological path that asks to focus on relevant involved actors. On the other, it presents some shortcomings when it comes to making a step backward and having the broader view asked by zooming out in order to connect several elements around the issue of interest.

Take for instance the concept of the boundary object. It is very useful to interpret social situations where unmatchable perspectives are in place to see whether collaboration in absence of consensus emerges (Star & Griesemer, 1989). However, it is one of the concept's proponents in person that stated that this concept is mainly useful when dealing with the organizational level, while it diminishes its values in other settings (Star, 2010). In the considered case of DCT, the concept of boundary object, and in general the SCOT and ANT traditions as part of the broader domain of Science and Technology Studies, do not offer very timely suggestions when engaging in the attempt of zooming out of the studied matter.

As shown in chapter one, this issue was raised also by critics of SCOT who lamented the absence of the idea of a social structure, a wider context, or a milieu around the actors and the relevant social groups, which could influence the way they shape the technology (H. K. Klein & Kleinman, 2002; Russel, 1986). It should be noted that the proponents of this approach addressed this specific critic claiming that "all forms of sociological explanation in which groups or structures are identified can never be adequate in the sense that all groups and structures are themselves embedded within an endless web of other groups and structures. Spelling out all such contexts is clearly impossible. All that can be attempted is to spell out sufficient context

for the purposes at hand" (Pinch & Bijker, 1986, p. 353).
Nevertheless, this element can be considered one of the cons of relying on this approach. That is why, for instance, based on the way the research was structured, it was problematic to provide specific answers to additional later questions such as the one reported in the previous chapter, namely why the different EU national governments managed DCT through different ministries. Perhaps a scholarly tradition focused on differences between EU political systems or on differences between the structures of the political bodies (Mair, 2006), or maybe focused on the varieties of capitalism (Nölke & Vliegenthrt, 2009) could have offered some more suggestions. Clearly, exploring also this path would have constituted at least half of a dissertation on its own, focusing on other research questions and aims, justifying – at that point – another body of literature compared to the one that was selected here, which would have probably missed on the socio-technical component of the considered phenomenon.

Another shortcoming of the SCOT approach is the lack of consideration of the temporal dimension. When considering the development of new technologies through the eyes of most relevant actors, paying also attention to the role of non-human ones, time does not find a proper spot.
The analysis that has been carried out in this work showed that time played a key role in the development of CTAs. Designers and developers were pressured by tight deadlines and needed to develop a technical solution as fast as possible. The same time constraints largely influenced the different actors that could be involved in the design of the intervention, as reported by the member of the German RKI who worked on the CoronaWarnApp.
The issue of temporality in pandemic management has been already addressed also picturing the shortcomings of the surveillance perspective on this issue (Birnhack, 2023). The present work showed that temporality played a key role when considering pandemic management with SCOT lenses, which are equally weak on this issue. Therefore, when adopting this theoretical framework in future works it would be proper to include reflections on the temporal dimension of construction of technologies. In general, it could be stated that, to adhere to the general principle of following the actors, the temporal dimension should be properly addressed by considering issues such as whether involved actors acted under pressure or not, or whether the technology was designed and developed in a quick fashion or a more processual and relaxed one. Acknowledging the temporal dimension would contribute to build a more complete picture of the analyzed topic.

Despite the reduced help that comes from the main considered scholarly tradition and the primary focus of this work dedicated to the analysis of the implementation of a healthcare policy through digital technologies, a zooming out effort is necessary to avoid flatness on DCT. As much relevant the case study can be on its own, broader implications from the academic debate point of view are important too, also because they quite clearly emerge from the analysis.

Indeed, some initial more general considerations have been presented in the previous chapter as well. Therefore, recalling those elements and largely referring to the three streams of literature that have been introduced in chapter two, some more reflections can be elaborated.

1.1 Healthcare and digital technologies: better defining the role of tech firms as gatekeepers of closed ecosystems

The findings on technology governance and the role of digital platforms as infrastructures offer the chance for general considerations related to the interplay between the healthcare domain and the digital domain. Recently, these two domains have been getting closer to one another, with applications such as telemedicine or mobile health, and seem to be oriented towards a tier bond in years to come (Bhavnani et al., 2016). In general, it could be argued that digital technologies are the means to achieve the aim of more efficient and effective healthcare: the case of DCT started exactly this way. At this point, it should be fairly clear that DCT during the COVID-19 pandemic was initially presented as a digital solution to tackle some of the problems that emerged with manual contact tracing (Ferretti et al., 2020). However, the findings of this work suggest that the balance in the relationship between the digital and the healthcare domain is changing. From being the means to improved healthcare, digital technologies are becoming the aim to which healthcare needs to adapt if it wants to rely on them.

In the studied case of DCT, such a reconfiguration emerges when considering the role of the smartphone ecosystem, as described by *Interviewee F*, who participated in the design of tracing protocols at the EU level.

> *The way our smartphones work today… the world market is basically constrained by two private companies, that is, the operating systems that work are from two private companies. These operating systems, the way they are designed, even arguably for valid reasons, defines which applications can run because permissions are required. This is managed in a completely...it is not arbitrary... but it is dictated by them. Let's say this thing in the area of computers has not happened because we still have to say... everybody in a machine can also install an operating system that is not from Microsoft or Apple. We have this freedom over there, while in the world of smartphones... yes okay maybe it is possible that you can make yourself a smartphone on which you install another operating system, however, in practice, it is not like that because if you want to use the apps that the whole world uses you have to agree to the terms of these companies.*
>
> Interviewee F

Compared to other technological ecosystems of the digital domain (e.g.: computers), the smartphone one is quite closed. Access to this ecosystem is then controlled by two digital platforms, Apple and Google, that have been properly defined as gatekeepers by several scholars (Khan, 2018; Srnicek, 2017; van Dijk et al., 2018). As shown in chapter 2, this concept is strictly related to the infrastructural feature of some digital platforms, that "form the heart of the ecosystem upon which many other platforms and apps can be built.

They also serve as online gatekeeps through which data flows are managed, processed, stored, and channeled. Infrastructural services include search engines and browsers, data servers and cloud computing, email and instant messaging, social networking, advertising networks, app stores, pay systems, identification services, data analytics, video hosting, geospatial and navigation services, and a growing number of other services" (van Dijk et al., 2018, p. 13). As presented, the literature on platforms as infrastructure is a rich one (Plantin et al., 2018; Srnicek, 2017; Van Dijck, 2020; van Dijk et al., 2018) and it properly argues that these firms have become almost essential for interactions between users, either for business activities, social interchanges, information seeking, or entertainment. However, the concept of platform infrastructure kind of loses a pivotal component that the "gatekeepers" ideas subtend, namely the idea of closed digital ecosystems. Talking about infrastructures evocates the openness of the digital domain, underneath which runs a network of services and technologies, developed and controlled by digital platforms, that constitute – indeed – its infrastructure.

Conversely, the analysis of DCT development in Europe suggests a slightly different configuration of the whole picture, that, yet conserving the main features of the aforementioned concepts, redesigns the scheme toward a model that could help understand some of the dynamics happening between different actors. As just said, most of the elements of this reconfiguration are already present in the current literature, the two main concepts included, namely ecosystem and gatekeepers. However, to the best of our knowledge, such reconfiguration has not been yet proposed, and its implications could offer an innovative perspective on this largely researched issue.

Let us get back to the case of DCT for a moment. It has been shown that, for improving manual contact tracing efficiency, which is a key component of the fight against the virus from a healthcare point of view, smartphone apps were developed in several countries. Moreover, it has been shown that Apple and Google played a key role in shaping some of the features of this technical solution before easing its introduction to their mobile operating systems. Clearly, this situation configures a scenario where several actors, from developers to public institutions, needed to adapt their values and aims to the values and aims of the gatekeepers of the closed ecosystem they aimed to access.

Take for instance the case of the Italian local healthcare authorities. As shown in previous pages, healthcare professionals needed digital tools to improve their monitoring activities of the diffusion of the virus. However, their needs clashed with the needs of the digital perspective toward DCT, which was mainly focused on privacy and data protection. Such a privacy-centric view was the same one carried out by Apple and Google that declared to aim at users' privacy protections from national government surveillance threats. These arrangements of power (DeNardis, 2012) of the "here-and-now" of DCT suggest a specific configuration in the "elsewhere-and-then" of the general mobile digital technologies-healthcare relationship. In contemporary times where the difference between the online world and the offline world is getting thinner (Floridi, 2015), despite public institutions playing a role in the early development of many digital technologies

(Mazzucato, 2021), the role of capitalism is pivotal (Greene, 2018; Peters & Jandrić, 2019; van Dijk et al., 2018) and it pushes towards closure and privatization of digital ecosystems. Therefore, closed and privatized digital ecosystems, such as the smartphone one, do not seem to be means to reach specific aims, such as better NPIs against COVID-19. At this point, even a healthcare policy seems just another way to make the digital, and its connected actors, stronger, more influential, and ultimately essential. Therefore, with respect to current global governance of digital technologies, private actors seem to be more influential than public ones.

However, within the present digital domain, not all technological ecosystems are as closed as mobile devices' one. As new technologies get developed, the rush toward privatization starts. However public institutions can and have to act to protect spaces of autonomy from the gatekeeping ambitions of private firms. The GAIA X project, which aims to develop an EU consortium for cloud computing, is oriented toward this direction (Darnis, 2020).

Since the many components of the digital domain already play a key role in many human activities, full private control could generate some of the situations that have been analyzed throughout this work; where, if the values and aims of the public institution match the ones of the tech firms, access to the closed ecosystem is eased, otherwise it is hindered. Such an understanding of the role of digital platforms as actual or possible gatekeepers of several digital technologies ecosystems seems a more precise way to consider the role of these actors in contemporary times.

1.2 Privacy: from an individual to a collective matter, and its domain dependency

Within this analysis, privacy did not just work as a sort of selection criteria to enter the closed mobile ecosystem controlled by Apple and Google, but it was also a topic largely addressed by designers and developers, whose activity suggests further consideration of this issue as well.

In chapter two it has been shown how privacy is traditionally considered an individual matter (Helm & Seubert, 2020; Huey, 2012). Such a stance influences the policies that regulate how it is managed in the digital domain, namely mainly as an individual right to choose either to accept or not privacy terms and conditions to opt-in online services (Fairfield et al., 2015). Next to this perspective, other authors argued that users usually do not have full information to evaluate the privacy implications of their online behavior (Acquisti et al., 2015; Hatamian et al., 2019). That is why, some scholars started suggesting that privacy should be considered a collective matter and not an exclusively individualistic one (Fairfield et al., 2015; Sætra, 2020).

Getting back to the empirical case of the development of Immuni, based on how privacy was managed in Italy, it could be argued that a collective approach to this issue was somehow applied. First of all, the analysis of users' reviews showed that they did not tackle the issue of privacy that much, and when they did, they

largely discounted it saying that Immuni was too privacy-protective. Conversely, experts involved in the design and implementation of the app largely reflected on this issue, considering the different harms for the users of a DCT solution not strongly oriented towards privacy and data protection. This approach is quite visible in the choice carried out in Italy on the use of GPS. Instead of leaving the choice of GPS open to the single user, the designers decided that information about the location was not essential in the tracing strategy, since it could have complicated even further the pseudonymization of data (Ministro per l'innovazione, 2020c, 2020d).

As already argued in a contribution based on this research that will be soon published: "this approach to a complex privacy issue seems a way of handling it as a collective matter, and not as an exclusively individual one, as contributions from many disciplines suggested (Coll, 2012; Helm & Seubert, 2020; Taylor et al., 2017). The burden of the choice is held by experts that have the competencies and time to discuss all the nuances of a specific technology's implication on data protection. With respect to DCT, privacy and data protection did not seem as exclusively individual issues anymore (Fairfield et al., 2015)".

The way privacy and data protection were managed in Italy during the development of the official CTA, could show a possible future way of managing these issues also in the "elsewhere-and-then". Of course, the user is still in charge of a sort of decision on his or her privacy, because s/he could always decide to not download or use digital technology. Nevertheless, whether s/he would decide to engage with it, his or her privacy would be granted by design (Solove, 2021). Such an approach could be also applied to many other activities online, surpassing the idea of "informative consent" which clearly makes privacy and data protection an individual matter, when instead is far more than that (Helm & Seubert, 2020; Huey, 2012).

Getting back to the relationship between the digital domain and the healthcare domain addressed in the previous paragraph, reflections with respect to privacy can be elaborated as well. As the example of Italian healthcare authorities showed, the conceptualization of privacy is very domain specific. The healthcare operators wished to have as much data as possible to try to understand the pandemic evolution and explore possible interventions to slow it down. Conversely, those actors that participated in the design of Immuni and had a digital technology background insisted on the importance of data minimization.

From a general point of view, privacy is then an issue that seems highly negotiable based on the interests and values of the actors involved. Privacy, or more properly data management procedures, are highly dependent on the power relations that develop in specific settings. In this work it has been shortly presented the EU data protection regulation, the so called GDPR, which provides a general common framework for data management. However, its application is highly dependent on the sector in which it is involved, if not from a strictly legal point of view, at least from a general understanding of its aims, based on the use of data that seem more proper in each context.

With respect to the healthcare and digital technology domain in the development of DCT, the vision and

perspectives of actors that are part of the latter emerged. Such an arrangement of influences also adds strength to the perspective that the healthcare domain, if it is interested in building interactions with the digital one, is brought to adhere to its rules, values, and principles even if they do not fully match with its own ones.

As already addressed in the previous chapter, in an extraordinary scenario such as the COVID-19 pandemic, the healthcare domain largely influenced political choices that often intervened on core freedoms of citizens, such as freedom of movement with several closings and lockdowns. However, the primacy of the healthcare reasons in the COVID-19 management was not able to influence some of the principles and stances of the actors involved in the digital domain, privacy and data management foremost. Once again, the digital domain, through the closed mobile ecosystem, was not an aim for better healthcare, to whose necessities the former needed to adapt. The digital domain and its closed ecosystems, controlled by private actors, have their own rules and principles to which actors from other domains need to adapt, also when privacy and data protection are involved during the emergency of a pandemic.

The contributions that this work could aim to make are not limited to the analysis of a very interesting element (DCT implementation through CTA) of a "total social fact" (COVID-19 pandemic) (Alteri et al., 2021), nor to engage with existing literature, showing confirmed trends, or suggesting additional developments. First of all, some reflections on the methodology employed in this study could be expressed, showing how combining different techniques could work as a useful strategy when analyzing complex social phenomena that somehow involve the digital domain. Then, from the analysis of the design, implementation, and use of DCT and CTAs some sort of implications or suggestions could be gathered to guide the future development of policies through digital technologies.

2. Methodological suggestions coming from the study of DCT

Of course, this contribution did not invent anything from the methodological point of view. Despite being a not-so-popular approach, fortunately, the analysis of users' reviews is a well-documented technique in the literature (Hoon et al., 2012; Vu et al., 2015). It could be interesting to stress the relationships between two similar-sounding principles that guided the empirical inquiry of this work. It has been already mentioned several times as the SCOT and ANT idea of "follow the actor" (Baron & Gomez, 2016; Bijker & Law, 1992) also suggested relevant methodological approaches. This principle could be connected to a similar one coming from the digital methods traditions, namely "follow the medium" (Rogers, 2009). The combination of these two "follows" could be considered a valuable research strategy when studying the development of innovation in general. On the one hand, following what most relevant actors did and how they behaved in the process of interest could be a very informative approach to shed light also on the nuances of the selected issue, leaving a superficial idea of linear innovation development behind (Bijker & Law, 1992). On the other, especially if the research involves digital technologies, focusing also on the medium could provide additional

information that could enrich the analysis. In the considered case, analyzing users' reviews gave the chance to add a further perspective of one of the most relevant actors in the whole process of design, implementation, and use of DCT through CTAs. Other more standard techniques were obviously available to reach similar aims but carrying out surveys or interviews with users would have probably suggested different dimensions with respect to those emerging from the analysis of content posted online. Within a research project so largely focused on the digital artifact, having a research approach that addressed the issue also from a natively digital point of view seemed preferable.

Of course, the study of a social phenomenon through digital methods, such as the analysis of user's reviews, besides its many strengths has some weaknesses. They have been attentively considered in chapter three, but once they are kept under control, the pros coming from such an approach largely overcome the cons. Furthermore, applying the principle of "follow the medium" through digital methods works best if supported by additional empirical information coming from diverse research techniques. That is why in this contribution data coming from two additional sources of information, gathered with more standard research techniques, namely semi-structured interviews and document analysis, has been included. The combination of these approaches seemed a valuable strategy for carrying out a broad, but at the same time deep, analysis of the issue of interest. Perhaps, how the research has been designed in this contribution could provide some suggestions for future works having similar aims.

3. Policy suggestions coming from the study of DCT

The study of DCT design, implementation, and use in Europe which has been carried out in this work could offer many relevant suggestions for future developments of public policies through digital technology as well. The COVID-19 pandemic prompted the use of digital technologies especially in healthcare-related policies (Budd et al., 2020), but the applications of them is clearly not exclusively related to this domain. The three suggestions that are now going to be developed could be succinctly described by a claim largely used in STS: "technology is never purely technological: it is also social. The social is never purely social: it is also technological" (Law and Bijker, 1992). Hopefully, future policies relying on digital technologies will not need to bridge the gap between the biological world of viruses and the digital one of electronic devices, nor would they need to be implemented extremely fast due to the pressure of an expanding pandemic. Despite DCT being related to these very particular circumstances, it could offer guidelines also for "peacetime". First of all, the development of Immuni, StopCovid and TousAntiCovid, and the Corona-Warn-App confirms that, when developing digital technology, the involved actors play a key role. Through their interests, values, and priorities they shape the technological artifact through which the policy is implemented. Therefore, considerable attention should be dedicated to the selection of actors involved in the development of such technology. If an actor is considered pivotal in the final phase of the policy's deployment, it should be somehow involved in the early phases as well. Not having pivotal actors participating in the designing of the technology may result in very significant later problems, like the one experienced in Italy with local healthcare

authorities. Obviously, not all the scenarios are proper ones for broad participatory design and development processes, and DCT during COVID-19 surely was not one of those due to the short time available. That is why, when circumstances are not favorable, the actors in charge of the design of the technology should design it accordingly. It is the case of the German public institutions with the CWA. Knowing that they could not involve the many local healthcare authorities in the design process and knowing that the local authorities were already overwhelmed by the manual contact tracing, they decided to leave them out of the DCT procedure, avoiding the risk of giving them a tool that was not tailored to their needs, as it happened in Italy.

The second suggestion that could be drawn from the case studies on DCT in Europe is related to the features and affordance of the designed and implemented technology. Digital technologies, which in the considered issue of research are apps, are quite flexible objects that could be fairly easily updated, intervening on their *scripts*. The analysis of the three CTAs showed how flexible apps which underwent constant updates, or a general reboot, performed better, at least from the point of view of users. Incorporating suggestions and critiques from this very important group of actors could be a valuable principle for future policy implementations through digital technologies. Of course, the aims and goals of digital technology are set by designers, but since digital technology can easily afford that, constant updates should be strongly considered based on the suggestions of users/citizens, but also based on the change in the setting, such as the introduction of vaccines in the considered case.

The third and last main policy suggestion that could emerge from this analysis is related to the issues of inequalities and exclusion. It has been shown that DCT through CTAs had the peculiar characteristics of being a public policy carried out through personal devices, controlled by private firms. Some of the reviews considered in previous chapters showed how some people, despite wanting to download the CTA, cannot do it because of not up-to-date smartphones. Furthermore, smartphone penetration in Europe is around 76% (Statista, 2022b), a quite high number, but very far from the totality to which a policy such as DCT should aim. There is no easy way out of this problem. Smartphones were the best solution available for the analyzed policy, and having some citizens excluded from the chance of participating in DCT was for sure a tradeoff, even if not largely discussed by those involved in the design and implementation of CTAs. In future developments of policy through digital technologies, these issues of inequalities and exclusion should be, at least, attentively acknowledged, and where there will be the chance, they should be tackled and managed.

In general, also building on the considerations carried out in this final chapter, a path toward proper public governance of digital technology needs to be established. It has been shown that DCT suggests that the governance of digital technologies nowadays is largely influenced by private actors that control some closed digital ecosystems and aims to extend their influence toward emerging ones. Of course, the goal should be to protect spaces of public autonomy in emerging technologies, the mentioned example of GAIA X is oriented toward this very direction. However, there should be also a real and strong endeavor to renegotiate the

governance of existing digital ecosystems. It is no easy task since, once private tech companies established their gatekeeping positions, they do not want to leave the gate to the ecosystem open and they aim to set rules and principles oriented toward maximizing their profits. Nevertheless, public institutions, in Europe for sure at the communitarian level with the EU, need to find innovative policy solutions to change the status quo.

This was the final step of an analysis that engaged with very different, broad, and complex topics. The hope is that these pages helped better understand a very interesting phenomenon that happened quickly, involving many different actors, and having different outcomes from what was initially hypothesized. Furthermore, the hope is that this analysis offered interesting suggestions to read some of the dynamics of present times, especially related to the design, implementation, and use of digital technology. Finally, the hope is that the timely consideration of the development of DCT through CTAs could offer some sort of insights on mistakes to avoid with respect to the development of policies through digital technology in many other fields which are not – we all hope – future pandemics' management.

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Appendix

1. Interview example

More specifically, these questions were used for interviewing *interviewee U* as reported in *Table 7* in chapter 3.

Dario Pizzul
PhD Analysis of Social and Economic Processes

UNIVERSITÀ DEGLI STUDI DI MILANO BICOCCA

Digital contact tracing

Different protocols

Before that singular digital contact tracing solutions were implemented at the national level, across Europe debates on centralized/decentralized approaches, privacy violation, and different protocols started to emerge.

- Could you please take me through what you understood happened in Europe during the first phase of the pandemic regarding digital contact tracing? We can maybe talk about how the different groups emerged behind each protocol, whether there was a clear leadership behind them, how you got involved, and whether there was optimism around digital contact tracing solutions, etc.
- Within the European debate on digital contact tracing, what do you think have been the main discussed issues, the most relevant stakeholders, and their interests?
- Do you think that the tracing solutions developed in Asia gave some indications on what was best to do in Europe?

National solutions

Starting from June 2020, the main European countries started to implement digital contact tracing solutions. Most of them relied on Apple and Google APIs, which followed a decentralized protocol largely inspired by the DP-3T's work. On the other hand, France decided to implement a centralized protocol, stating that digital sovereignty was involved when dealing with digital contact tracing solutions.

- What kind of role do you think Apple and Google had in developing digital contact tracing solutions?
- Why do you think France decided to use a centralized approach? Do you think that a digital sovereignty issue actually emerges?

Digital contact tracing in Germany

- Initially, Germany, along with France, was supporting the centralized approach, why do you think they decided to switch to the decentralized one?
- What is your general evaluation of digital contact tracing in Europe and in Germany?
- Which have been the strengths and weaknesses of digital contact tracing in Europe and in Germany?

2. Scraping script for Italian reviews

```
const gplay = require('google-play-scraper')
const fs= require('fs')

gplay.reviews({
  appId: 'it.ministerodellasalute.immuni',
  sort: gplay.sort.NEWEST,
  country: 'it',
  lang: 'it',
  num: 50000
}).then((x) => {print(x)}, console.log)


function print(x) {
  console.log('Length: ', x.data.length)
  fs.writeFile('newfile.txt', JSON.stringify(x, null, 2), (e) => {})
}
```

3. Script for data analysis of Italian reviews

```
# reading in the dataset
df = pd.read_csv('Immuni_dataset.csv', encoding='utf8', sep=';', engine='python')
df.dtypes

#Tokenize review in new column
df["Trigrams"] = df["Review"].apply(word_tokenize)

#Clean the words of punctuations and stop words
def clean_text(clean):
    clean = [x for x in clean if x not in string.punctuation]
    clean = [x for x in clean if x not in italian_stopwords]
    clean = [x for x in clean if x.isalpha()]
    clean = [x.lower() for x in clean]
    langdata = simplemma.load_data('it')
    clean = [simplemma.lemmatize(x, langdata) for x in clean]
    return clean


df["Trigrams"] = df["Trigrams"].apply(clean_text)

#Ngrams
df["Trigrams"] = df["Trigrams"].apply(lambda row: list(nltk.ngrams(row, 3)))

#Export to excel
df.to_excel(r'C:\Users\Lenovo\OneDrive\Documenti\ASEP\Dissertation\App\Trigrams_bydate2.xlsx', index = False)
```

4. Top20 most recurring trigrams for each analyzed case

	France	Germany	Italy
Technical issues	scanner, qr, code *(scan, qr, code)* dernier, miser, jour *(last, update)* miser, avoir, jour *(update)* désactiver, tout, seul *(deactivate, all, alone)* vérifier, connexion, internet *(check, connection, internet)* depuis, miser, jour *(since, update)* depuis, dernier, miser *(since, last, update)* avoir, chaque, fois *(have, each, times)* obligé, désinstaller, réinstaller *(forced, uninstall, reinstall)* bluetooth, low, energy connexion, internet, alors *(connection, internet, then)* impossible, scanner, qr *(impossible, scan, qr)*	Fehler, Kommunikation, googeln *(error, communication, google)* Kommunikation, googeln, api *(communication, google, api)* seit, letzt, Update *(since, last, update)* Ursache, schief, laufen *(cause, wrong, working)* Ursache, Fehler, Kommunikation *(cause, error, communication)* schief, laufen, Fehler *(wrong, run, mistake)* qr, Code, scannen *(qr, code, scan)* laufen, Fehler, Kommunikation *(run, error, communication)* deinstalliert, neu, installiert *(uninstalled, new, installed)* googeln, play, Dienst *(google, play, service)* App, mehr, öffnen *(app, more, open)*	google, play, service consumare, troppo, batteria *(use, too much, battery)* dire, notifica, esposizione *(say, exposure, notification)* notifica, esposizione, attivare *(exposure, notification, active)* abilitare, notifica, esposizione *(enable, exposure, notification)* attivare, notifica, esposizione *(activate, exposure, notifiction)*
Useful	très, bon, application *(very, good, application)* fonctionner, très, bien *(work, very, well)* application, très, utile *(application, very, useful)* très, bien, très *(very, well, very)* très, bien, faire *(very, well, do)*	finden, App, gut *(find, app, good)*	potere, essere, utile *(can, be, useful)* app, ben, fare *(app, well, done)* fare, molto, bene *(app, very, well)* app, molto, utile *(app, very, useful)*
Useless	servir, avoir, rien *(use, have, nothing)*	leider, funktioniert, App *(unfortunately, work, app)*	non, servire, nullo *(useless)* non, servire, niente *(useless)* a, cosa, servire *(what, is, for)*
Positive contacts		positiv, testen, warden *(positive, test, become)* positiv, getestet, Person *(positive, tested, person)* Begegnung, niedrig, Risiko *(encounter, low, risk)*	essere, stato, contattare *(being, contact)* contattare, persona, positivo *(contact, person, positive)* stato, contattare, positivo *(be, positive, contact)* persona, risultare, positivo *(person, tested, positive)*
Temporal dimension		App, seit, tagen *(app, since, days)* seit, erst, tagen *(since, first, days)* seit, tagen, tagen *(since, days, days)*	
Other	tout, anti, covid (name of the app) ce, application, très *(this, application, very)*	corona, warnen, App (name of the app)	dovere, essere, obbligatorio *(must, be, mandatory)* cosa, dovere, fare *(what, need, do)* non, capire, funzionare *(not, understand, work)*

5. Top30 most recurring bigrams for each analyzed case

France	Germany	Italy
ce, application this application	qr, Code qr, Code	non, funzionare doesn't work
très, bien very, well	seit, tagen from, days	dovere, essere has to be
miser, jour update	App, funktioniert app, works	notifica, esposizione exposure, notification
qr, code qr, code	gut, App good, app	molto, utile very, useful
bon, application good, application	App, gut app, good	non, servire useless
très, pratique very, practical	funktioniert, App works, app	potere, essere may, useful
très, utile very, useful	googeln, api google, api	servire, nullo use, nothing
très, bon very, good	Kommunikation, googeln communication, google	app, inutile app, useless
ce, appli this, app	Fehler, Kommunikation error, communication	non, capire don't, understand
tout, seul all, alone	finden, App find, app	consumare, batteria drain, battery
application, très application, very	App, seit app, since	servire, niente useless
chaque, fois each, times	positiv, testen positive, test	segnalare, positività signal, positivity
cas, contact case, contact	App, laufen app, work	ben, fare weel, done
avoir, jour have, day	App, nutzen app, use	ottimo, app great, app
tout, monde all, world	App, mehr app, more	risultare, positivo resulted, positive
connexion, internet connection, internet	seit, Woche since, week	huawei, lite
fonctionner, très work, very	testen, werden test, become	essere, utile be, useful
servir, rien use, nothing	corona, App corona, App	funzionare, bene work, well
pouvoir, être can, be	laufen, App work, app	persona, positivo person, positive
ça, fonctionner it, function	neu, installiert new, installed	contattare, positivo contact, positive
facile, utiliser easy, use	erst, tagen first, days	non, riuscire not, able
impossible, télécharger impossible, download	Ergebnis, App result, app	cosa, servire what, for
mettre, jour put, day	letzt, Update last, update	sempre, attivo always, on
nouveau, version new, version	App, immer app, always	dovere, fare have, do
mise, jour put, day	viel, danken big, thak you	**operatore, sanitario** **healthcare, worker**
désinstaller, réinstaller uninstall, reinstall	App, zeigen app, show	secondo, me to, me
fonctionner, bien function, well	nutzen, App use, app	ogni, volta every, time
ça, marche it, works	warnen, App warn, app	totalmente, inutile completely, useless
impossible, activer impossible, activate	App, installiert App, installiert	entrare, contattare be, contact
bien, faire well, do	App, deinstalliert App, deinstalliert	inutile, non useless, not