Chapter 6
The use of ICT services and tools by PRO research personnel in agile working during the COVID-19 pandemic

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ABSTRACT
With the outbreak of the COVID-19 pandemic, the Italian public administration had to resort to a massive activation of agile working in a situation characterized by chronic delays in widespread adoption of ICT solutions, as well as a state of inertia in providing adequate training for staff on the use of technological services. While organizations attempted to respond to the emergency by providing new tools and services for remote work, many employees, at least in the first phase, were forced to deal with the skills acquired independently in order to use ICT services available and seek solutions to any technical or operational problems. Even knowledge workers, who are highly qualified and potentially predisposed to autonomous and innovative ways of performing research activities, had to adapt to new work dynamics characterized by an increased use of ICTs. This contribution aims to describe the mode and intensity of use of ICT services and tools by non-academic research personnel during agile working performed in emergency. The interest is primarily focused on the individual early adoption or increased use of ICT resources in response to out-of-office working conditions, regardless of the degree of physical IT equipment eventually provided by organizations. The investigation focuses on the following topics: i) the research personnel's approach to using ICTs for agile working, taking into account individual and organizational preparation; ii) the use experience of ICT tools and services during agile working, enlightening which of them could have played a potentially transformative role in the organization of work; and iii) the main obstacles they encountered in using ICTs in agile working.

KEYWORDS: ICTs, agile working, smart working, remote work, research work.

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1. INTRODUCTION

With the outbreak of the COVID-19 pandemic, the Italian public administration had to resort to a massive activation of agile working in a situation characterized by chronic delays in widespread adoption of ICT solutions, as well as a state of inertia in providing adequate training for staff on the use of technological services (see ISTAT, 2020). While organizations attempted to respond to the emergency by providing new tools and services for remote work, many employees, at least in the first phase, were forced to deal with the skills acquired independently in order to use ICT services available and seek solutions to any technical or operational problems. Even knowledge workers, who are highly qualified and potentially predisposed to autonomous and innovative ways of performing research activities, had to adapt to new work dynamics characterized by an increased use of ICTs. The ability to adapt to their use and potential is a critical driver of organizational change and can affect both the quality and perceptions of benefits and drawbacks (Albano et al., 2019; Butera, 2020; Loré & Frey, 2020).

The purpose of this contribution is to investigate the research personnel's use of ICT tools and services during agile working in an emergency period. The interest is primarily focused on the individual early adoption or increased use of ICT resources in response to out-of-office working conditions, regardless of the degree of IT physical equipment possibly provided by organizations. Data are provided by the online survey on the effects of agile working in Italian Public Research Organisations (PROs), which was conducted by CNR-IRCrES (see Chapter 2) and targeted to the National Institute of Astrophysics (INAF) and the research institutes belonging to the National Research Council (CNR). The investigation focuses on the following topics: i) the research personnel's approach to using ICTs for agile working, taking into account individual and organizational preparation; ii) the use experience of ICT tools and services, enlightening which of them could have played a potentially transformative role in the organization of work; and iii) the main obstacles they encountered in using ICTs in agile working.

This chapter is structured as follows: Paragraph 2 will briefly examine the digitalization processes in public administrations in light of the need to sustain remote work formats while also responding to the COVID-19 pandemic emergency; Paragraph 3 will focus on the use of ICTs in research practices; Paragraph 4 will introduce the dimensions of interest and the method used; Paragraph 5 will present the analyses based on the research questions, deepening the research personnel experience with ICTs during the performance of agile working in the emergency period. Finally, the conclusions will summarize the findings and discuss the opportunities provided by the “forced” agile working experience for improving ICT advanced solutions for the research sector.

2. THE VALUE OF ICTS IN THE DEVELOPMENT OF NEW WORKING FORMATS

The already pervasive presence of digital technologies in the daily lives of citizens and organizations has become critical when the COVID-19 pandemic made them even more necessary for performing a wide range of activities because of a drastic reduction in physical interactions and movements. The Italian government's decision to implement a shift from traditional office work to agile working (mostly performed at home at a first stage) in “extended mode”, affecting both the public and private economic sectors, forced organizations to increase their efforts to provide ICT services and tools for remote workers. In this regard, the level of organizational preparation between the private and public sector differed significantly. According to the data from the Observatory on Smart Working of the Politecnico di Milano, before the outbreak of the pandemic, 50% of large private companies adopted work from remote one/two days a week, while the percentage drops to 16% for public administrations (Butera, 2020). When dealing especially with the public sector, organizations responded to the need for reorganization by speeding up a previously fragmented and discontinuous path through digitalization (ISTAT, 2020).

High capacity of organizational adaptation is required to implement the agile working regime, and the development of ICT tools and services is a critical driving force behind this process. Though most studies in the literature related to the development of remote work types (see, for example, Rapp et al., 2006; Klehe & Anderson, 2007; Oliva, 2017) were mainly concerned with productivity, well-being and life-work balance issues, a number of contributions particularly highlighted the value of ICTs in the innovation of organizational processes (Albano et al., 2019; Butera 2020) and their role in the redefinition of places, times and working methods towards a progressive flexibility of activities. Furthermore, Loré & Frey (2020) pointed out that the realization of agile working requires the acquisition of digital skills also at the *individual* level beyond the *organizational* one, in line with what other authors theorized in the years preceding the pandemic (see Chiaro et al., 2015). In this regard, on the one hand, the implementation of agile working relies on investments towards the digitalization of many services and work activities and the training of the personnel on the new working formats; on the other hand, it is dependent on the resolution of a number of individual worker issues, such as domestic internet access and the empowerment of basic and advanced ICT skills.

2.1. Relaunching the digitalization process to support agile working

Between 2013 and 2017, all areas of Italy's public sector, with the exception of Healthcare, saw a consistent and widespread decrease in ICT spending, owing to the persistence of the effects of the economic and financial crisis and the resulting adjustment of public finances in accordance with the Stability Pact (see Agenzia per l'Italia Digitale, 2021). A reversal of the trend occurred in the following two years, when the central administrations recorded a constant increase in the spending for ICT goods and services starting from 1.5 billion euros in 2017 and forecast a 23% increase in 2020, amounting to approximately 1.9 billion euros (*ibidem*, p. 19). The forecast data took into account the impact of the COVID-19 pandemic on the government's push for more ICT investment and development in order to support the possibility for implementing agile working.

In compliance with the Action Plans and the European guidelines, Italy sets digital transformation objectives on several levels through multiple initiatives, from the *Transition Plan 4.0* (Ministero dello Sviluppo Economico, Decreto 26 Maggio 2020) in support of businesses to the *Three-Year Plan*[1] *for the digitalization of public administration* (Agenzia per l'Italia Digitale e Dipartimento per la Trasformazione Digitale, 2020), which will include the launch of a national platform for smart working in the public sector through the Smarter Italy program (Ministero dello Sviluppo Economico, Decreto 31 gennaio 2019).

A further step towards the digitization and development of IT systems to support agile working in public bodies, with reference also to PROs, was made through art. 36 of the Simplification Decree (Decreto Legge 16 luglio 2020, n. 76):

> Al fine di favorire la trasformazione digitale della pubblica amministrazione, nonché lo sviluppo, la diffusione e l'impiego delle tecnologie emergenti e di iniziative ad alto valore tecnologico, le imprese, le Università, gli enti di ricerca e le società con caratteristiche di spin off o di start up universitari di cui all'articolo 6, comma 9, della legge 30 dicembre 2010, n. 240, che intendono sperimentare iniziative attinenti all'innovazione tecnologica e alla digitalizzazione, possono presentare alla struttura della Presidenza del Consiglio dei ministri competente per la trasformazione digitale i relativi progetti, con contestuale domanda di temporanea deroga alle norme dello Stato, diverse da quelle di cui al comma 3, che impediscono la sperimentazione[2].

[1] https://pianotriennale-ict.italia.it/en/

[2] Translation by the authors: "In order to foster the digital transformation of the public administration, as well as the development, dissemination and use of emerging technologies and initiatives with a high technological value, companies, universities, research bodies and companies with spin-off or university start-ups characteristics referred to in article 6, paragraph 9, Law n. 240, which intend to experiment with initiatives relating to technological innovation and digitization, may submit the related projects to the structure of the Presidency of the Council of Ministers

The aforementioned initiatives share the goal of relaunching ICT development and speeding up the digitalization process in support of new forms of work; however, this effort cannot be separated from the enhancement of digital skills of the population, which is encouraged at the European level by the actions taken by the European Commission, such as the European Skills Agenda, which was adopted on July 1, 2020 (European Commission, 2020). One of the central points of the Agenda concerns *lifelong learning* and the development of basic skills for sustainable growth through an action plan for digital education; among the objectives for the next five years, the Agenda aims for an increase of 25% of adults with basic digital skills. Furthermore, in 2020, many EU programmes and investments were launched on the three pillars "Connectivity", "Digital Innovation" and "Human Capital" with the aim of increasing the percentage of the population with basic digital skills, introducing specialized training courses in public and private organizations, developing the infrastructures and spreading the broadband connection.

The improvement of the population's digital skills is especially important for Italy, which ranks 25th in Europe in terms of Human Capital with digital skills, according to the latest monitoring by the European Commission on the digital progress of EU27 member countries through the DESI Index (See DESI, 2021[3]). In this regard, the first Italian National Strategy for Digital Skills was launched in 2020, with specific actions aimed at reducing the gap with other European countries by 2025.

2.2. Latest data on ICT initiatives in public organizations

A picture of the latest ICT initiatives implemented by the Italian public institutions emerges from the third Permanent Census of Public Institutions of ISTAT[4], whose preliminary results were released on December 15, 2021, and which focused on the response to the COVID-19 emergency, highlighting the strategies and innovations in terms of internal organization and work.

Larger administrations have more effectively equipped themselves to provide the necessary IT equipment and organize communication and training initiatives aimed at promoting the optimal use of ICT resources. In particular, over 94% of State Administrations and public universities provided employees who did not have personal equipment with hardware devices (e.g. PC) to work remotely in all metropolitan cities, compared to 47.6% of the total of public institutions. The census shows a significant diffusion of technological equipment for secure remote access to data (57.8%) and software for remote collaboration (51.6%). The highest share of entities that have not provided their employees with technological equipment is registered by the non-economic public entities (30.6%, including PROs, marked with the red circle in Fig. 1), which consequently result the least provided for the two types of equipment (42.3% and 45.8%).

responsible for digital transformation, with a simultaneous request for a temporary derogation from the State regulations, other than those referred to in paragraph 3, which prevent the experimentation".

[3] DESI Reports and data are available at https://digital-strategy.ec.europa.eu/en/policies/desi. Another critical issue regarding Italy relates to the development of connectivity networks: in 2021, Italy ranked 20th among the EU27 countries despite the progress made especially during the pandemic (DESI, 2021).

[4] The last census is available at https://www.istat.it/it/files//2021/12/REPORT-ISTITUZIONI-PUBBLICHE-2020.pdf. In the first note released some data are presented, including those relating to the initiatives implemented by the public institutions subject to the census on digitization and enhancement of ICT to support remote work.

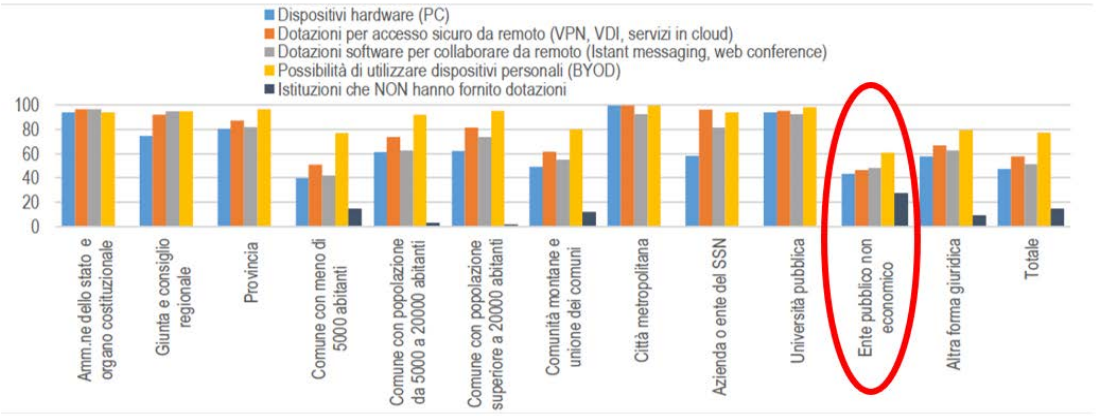

Figure 6.1. Public institutions by legal form and type of technological equipment provided. Percentage values. Year 2020. Source: ISTAT (2021).

Investments in technological equipment have surpassed those in communication and training initiatives, similarly with evidence emerging from the latest DESI monitoring (DESI, 2021). Only one out of four public bodies has implemented training and communication initiatives, albeit with significant variations between the types of bodies. Once again, non-economic public bodies are characterized by below-average investments in such initiatives to enhance the use of the available technological tools (Figure 6.2).

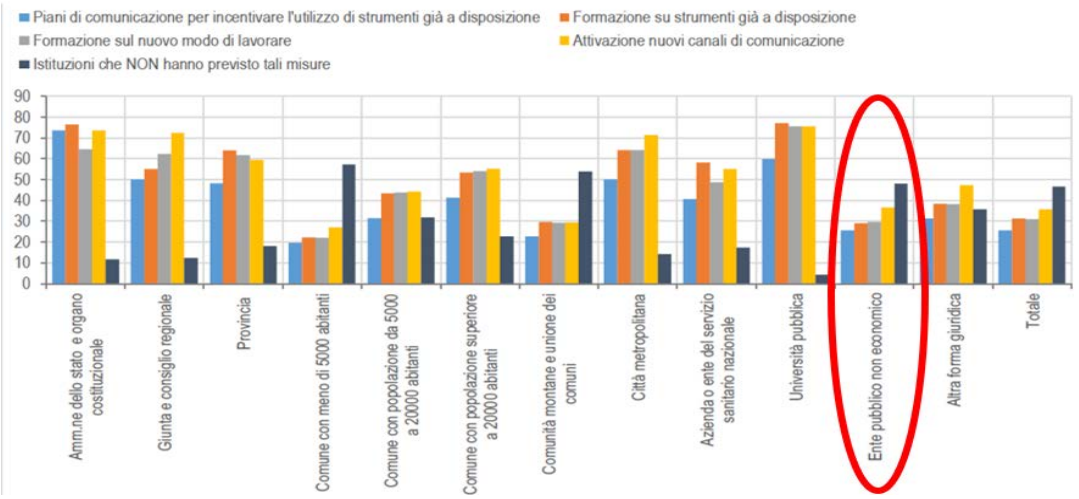

Figure 6.2. Public institutions by legal form and type of communication/training initiative. Percentage values. Year: 2020. Source: ISTAT (2021).

Another aspect, related to the impact of the sudden activation of agile working in public institutions during the COVID-19 emergency period, is the frequency of interactions within working groups, which is ensured remotely by ICT systems. ISTAT data show that this has remained unchanged in 50% of public institutions while it has increased in 30.5% of them, with peaks exceeding 61% in the case of State Administrations and Universities, which have also been more involved in equipping employees with the digital tools and skills necessary to be able to work remotely. Only 12.1% of institutions complain of a decrease in interactions within their working groups.

Statistics reported in the ISTAT census pertain to organizational-level monitoring, as opposed to the subject of this chapter, which is aimed at individuals with the goal of investigating PRO research personnel experiences with ICT during agile working implemented in an emergency. The sources cited are in any case helpful in defining the scenario in which the PROs are placed. The next paragraph will explore specifically the relationship between ICTs and the world of research, with the aim of completing the theoretical framework in preparation to delve deeper into the topic of the use of ICT services and tools by research personnel during agile working implemented in the emergency.

3. Adoption of ICTs in research practices

The use of ICT and web-based resources has had a consistent impact on scientific research activities, triggering new habits from both an institutional and organizational standpoint and proposing new routine models in knowledge production (Borgman, 2007). Over the last decade, a variety of new ICT tools and services have begun to emerge and be used by researchers for their work: chat and video conferencing programs, as well as services such as storing files on cloud platforms, using software on external servers and remotely accessing office resources have all become increasingly popular. Researchers are constantly engaged in a process of social learning that characterizes their use of Web 2.0 and ICT tools for their activities, and organizations have often equipped themselves with IT support services as evidence of the fact that the use of IT tools has become indispensable for research activities.

The adoption of new practices presupposes negotiations and discovery processes: on the one hand, potential ICT users "fight" to discover, explore and exploit new technological capabilities to adapt to their purposes and contexts; on the other hand, developers try to understand emerging users and uses, generating a potentially endless process of experimentation (Williams et al., 2005). With reference to the introduction of technological innovations in the work context, there is no clear consensus in the literature on the identification of determinants of ICT adoption. Venkatesh et al. (2003) tried to standardize the vast production of theoretical frameworks for the understanding and modelling of these processes, noting that each construct was strongly linked to the concept of *performance expectancy*, a composite indicator whose constituent elements are perceived usefulness, extrinsic motivation, relative advantage, job-fit and outcome expectations. In the model created by the authors, known as the Unified Theory of Acceptance and Use of Technology (UTAUT), performance expectancy is moderated by age and gender (the effect is stronger for young people and men) and defined as the degree to which an individual believes that using the system will help him or her achieve a gain in job performance.

With reference to knowledge workers, the use and diffusion of ICT tools for research does not appear to be similar across all disciplinary fields. It turns out that "hard science" researchers make more extensive use of new digital opportunities, whereas their adoption in the social sciences is less widespread and more heterogeneous, though a set of techniques, tools and dynamics has recently found its way into the digital humanities (see Dutton, 2010). While the findings of the Researchers of tomorrow report (JISC & British Library, 2012) emphasise that the new generation of researchers are not using digital technologies to their full potential, the data of Arcila-Calderón et al. (2015) conversely show how scientific outreach via ICT is becoming increasingly important for young researchers. In terms of specific ITC services, Pearce (2010) found that age can be a determinant in the adoption of tools geared towards scientific dissemination, while gender has a positive correlation with the rate of adoption and knowledge of other advanced tools geared towards data analysis and preservation.

Procter et al. (2010) and Ponte & Simon (2011) showed that an increasing number of scholars relied, or favourably expressed their intention to rely in the future, on new online communication practices to promote or disseminate a paper or article, but also to coordinate collaborative work or share digital research artefacts. Nonetheless, the two studies agreed on a degree of "conservatism" in the adoption of *new* digital tools or services. Many researchers still claim to rely on traditional mechanisms of information exchange that had been shown to work in the past,

thus following the trend of using tried and tested tools rather than making a risky investment in unexplored novelties. What emerged was that the proliferation of resources and the constant fragmentation of the offer of tools and platforms paradoxically encountered unexpected resistance from potential users, both because of the difficulty of keeping track of developments in new opportunities and the lack of information or preparation to assess the benefits for some types of activities. Nevertheless, where the benefits of adoption have been perceived as sufficiently high and the investment costs favourably low to motivate community adoption, new resources still manage to reach masses of users, generating network externalities leading to their pervasive adoption by particular communities. The authors identified the role played by local research groups and knowledge intermediaries, within departments or networks, as key determinants to stimulate the adoption of Web 2.0 services and tools through formal or informal means. In the same vein, Arcila-Calderón et al. (2015) applied the UTAUT model in research contexts, although with some variation, essentially confirming that performance expectancy – understood in this case as a set of expectations regarding the future of scientific productivity and the generation of new discoveries – was an important predictor of ICT use in the scientific environment.

Since February 2020, the relationship between ICTs and the world of research has necessarily been overcome by events, for the world has had to face social isolation and the redefinition of the organization of work because of the global pandemic emergency. Knowledge workers have been "forced" to make a massive use of ICT tools and services in order to continue working remotely, thus reviewing their relationship with them.

4. DIMENSIONS OF INTEREST AND METHODS

The analyses presented in this chapter are intended to describe the context and intensity of use of ICT services and tools available to non-academic research personnel who performed agile working during the COVID-19 pandemic period. The focus is on the characteristics of the individual adoption of ICT resources in response to out-of-office working setting, regardless of the degree of ICT equipment offered by organizations. The latter aspect will be explored only in terms of services offered, without delving into the provision of physical resources.

The research questions that lead the investigation are:

i. How did the research personnel approach the use of ICTs during agile working in emergency, taking into account their personal preferences and individual and organizational preparation?
ii. What was the research personnel experience with ICT tools and services during agile working, and which tools or services showed the potential to transform the individual work organization?
iii. What were the major obstacles they faced when utilizing ICTs during agile working?

The empirical base comes from the survey created within the project *Agile working in research institutions: organizational factors and individual behaviors in the production of knowledge*, developed by CNR-IRCrES (see Fabrizio et al., 2021; Fabrizio et al., § Chapter 2). Data from the survey will be first used to determine the importance of the office setting in performing research activities prior to the COVID-19 emergency, as well as how the organizations have introduced research personnel to agile working. Subsequently, the analysis will take a picture of the availability of ICT tools and services at home, including the type of internet connection available. These contextual data will help to better interpret the research personnel actual experiences with different ICT services and tools during agile working. For the purposes of this chapter, a selection of common ICT tools and services that can be used to perform agile working will be considered (see Table 6.1). A special emphasis will be put on the early use of ICT tools/services and their potential to change the organization of research personnel's work. Finally, data on technical limitations and difficulties encountered by respondents will be presented.

Table 6.1. List of ICT tools and services considered for the analyses presented in this chapter

ICT service/tool	Definition
Commercial cloud storage with private access	A data storage platform accessible by the user through private subscription or for free, which allows to sync and share data and collaborate. Physical storage is typically spread across multiple servers, and the physical environment is typically owned and managed by a hosting company. Some examples are Apple iCloud, Dropbox and Google Drive. It can be accessed through desktop client software, a web browser or an app.
Cloud storage made available by the organization	A data storage platform managed directly by the organization. It can be self-hosted or leased.
Virtual Private Networking (VPN)/ Proxy server	A method of securely accessing network resources by connecting to a remote access server through an encrypted connection. A proxy server allows access to the services of a private network from a public network upon authentication. This service can be used to connect the home computer to the office network, for example.
Programs for audio/ video conferencing	Programs for taking part in an online meeting or conference with two or more participants in different locations. Through a conferencing software, participants can see, talk and hear each other in real-time. Moreover, there are features like chat, screen sharing and recording. Some examples are Zoom and GoToMeeting.
Chat programs	Real-time communication between two or more users via networked-connected computers. In this category the survey included programs used for communication with a limited number of participants, e.g. Skype.
IT support service/ help desk	An information and assistance resource that troubleshoots problems with computers OS and application software, printers, network and other devices. The helpdesk can be provided by remote services, e-mail, phone and dedicated web pages info.
Shared online planning for research teams	Application for scheduling meetings and events quickly and receiving task reminders. They can be used for teams, making it simple to share schedules and create multiple calendars for use by other users. Some examples are Google Calendar and Teamup.
Use of specific software on the institution's server	Network services made available by the organization and run on the institution's server.
Remote access to databases	Access to resources bought by the organization (electronic journals, databases, e-books) from any workstations outside one's own organization.

A subset of the survey data has been elaborated with the SPSS software. The CUN scientific areas were grouped into the three research macro sectors established by the European Research Council (ERC sectors): Physics and Engineering (PE)[5]; Life Sciences (LS)[6]; Social Sciences and Humanities (SSH)[7]. All analyses consider the entire research personnel from CNR and INAF who took part in the survey (2,921 respondents). It should be remembered that almost all the INAF respondents (388 units) belong to the CUN 2 area (Physics) and therefore to the PE sector, while the CNR respondents (2,533 units) are distributed over multiple ERC sectors. In addition,

[5] Including the following CUN areas: 1 Mathematics and Informatics; 2 Physics; 3 Chemistry; 4 Earth Sciences, 8 Civil Engineering and Architecture; 9 Industrial and Information Engineering; Humanities.
[6] Including the following CUN areas: 5 Biology; 6 Medicine; 7 Agricultural and Veterinary Sciences.
[7] Including the following CUN areas: 10 Antiquities, Philology, Literary Studies, Art History; 11 History, Philosophy, Pedagogy and Psychology; 12 Law Studies; 13 Economics and Statistics; 14 Political and Social Sciences.

different numbers of respondents refer to each ERC sector (1,982 for PE; 706 for LS and 233 for SSH).

Data breakdowns were made based on age cohorts, gender (37 respondents were excluded from this type of analysis because they did not indicate their gender), ERC domain, type of activity and workplace's geographical location. For categorical variables, percentages were calculated using the number of valid responses as the denominator. An additive index was created based on weights applied to response percentages about the intensity of use of ICT tools/services (see Par. 5.3).

5. ANALYSES

5.1. Value of office setting and preferences for virtual modes before the emergency

In non-emergency times, research activities are carried out not only at the office but in a variety of locations: in fact, the Italian working rules on the autonomy of research personnel enable employees to work off-site, self-certifying the activities (see Chapter 3). In addition, working time is normally managed even outside the canonical office hours, with tasks frequently carried out at home[8]. Nevertheless, how important are the resources specifically present in the office, such as IT equipment like computers and printers or services like a fast internet access, in terms of the work needs of research personnel? In this regard, the survey included a general question about the need to rely on resources and materials available in the office. Although this question does not specifically address IT tools and services, it does provide insight into the predisposition to work remotely, which necessitates the use of different ICT resources.

In general, research personnel do not consider the office as essential to the performance of work. They have only a slight preference for using the resources available in the office (21.8% much, 35.5% enough), but the intensity of preference varies depending on the age cohorts, the ERC sector and the type of activity (Table 6.2). The importance given to office setting by the older cohort (55+) is greater than that attributed by the younger cohort (under 45): as age increases, the percentages attributed to the answers "important enough" and "much important" increase, while the percentages attributed to the answers "not at all" and "little important" decrease. As for the ERC sectors, working in an office setting is an almost essential factor for LS (28.5% much, 39.4% enough), whereas the preference from PE respondents is more muffled, with 36% of them reporting that it is of little importance. SSH respondents practically split in half (49.8% not at all plus little; 50.2% enough plus much), denoting a greater predisposition to the use of materials and resources that may not be present in the office. The difference between those who conduct experimental activities and those who conduct non-experimental activities is also significant. For the former, moving away from office resources is less preferable than for the latter.

[8] According to the data presented in Chapter 3, the preferred workplace for task performance is the office in any case, but with varying percentages depending on the task. Notably, between 20-30% of interviewees reported being indifferent to the place of work, whereas the "at home" mode represented more than a quarter of the choices for drafting papers and peer reviewing.

Table 6.2. "How important is the possibility to access materials and resources in the office?" Percentages on total respondents by age cohort, ERC sector and type of activity

	Not at all	*Little*	*Enough*	*Much*
30-44 age cohort	10.1	36.7	34.0	19.3
45-54 age cohort	10.2	33.0	35.4	21.4
More than 55 years cohort	6.4	31.2	37.2	25.2
LS	5.8	26.3	39.4	28.5
PE	9.6	36.0	34.6	19.8
SSH	13.3	36.5	30.9	19.3
Experimental activities	6.4	30.3	38.3	25.0
Non-experimental activities	13.6	40.9	29.8	15.7
Total	**9.0**	**33.7**	**35.5**	**21.8**

Note: LS = Life Sciences; PE = Physical Sciences and Engineering; SSH = Social Sciences and Humanities.

Even prior to the emergency and implementation of agile working, some research activities could be carried out without the need for physical presence. As we will see in section 5.3, chat or streaming software and services, such as Skype or Zoom, were already used by research personnel: they could be used to participate remotely in conferences or project meetings, carry out scientific dissemination through seminars, or even perform experimental activities such as field investigations or the implementation of operational research tasks. To what extent were streaming modes used in place of "in presence" modes for performing the aforementioned tasks before the emergency situation? In this regard, the survey asked respondents about their preference for streaming modes or their lack of preference between streaming or "in presence" modes.

Data reveal that the preference for streaming was doubtlessly marginal for all activities, with percentages never exceeding 5% of respondents (Figure 6.3). Preference for streaming modalities is in general lower for the older cohort (respondents over 55) than for the other age cohorts, but only for project meetings there is a significant difference (2.7% vs 6.1% for the 45-54 cohort and 5.5% for the under-45 cohort). In-person meetings were clearly preferred, and only project meetings and scientific dissemination were allowed to take place virtually in some cases. Participating in conferences in streaming mode was substantially not taken into account, but this data must be read in relation to the ability to connect remotely, provided by conferences in various disciplines. However, the percentages coming from the lack of preference between "in-presence" mode and streaming mode for project meetings are interesting: indeed, there is a noteworthy openness towards streaming modes (36% of respondents) particularly in the PE sector (38%), but also in the LS and SSH sectors (31.7% and 30.9%). As for scientific dissemination, the PE sector is the only one that shows some openness (38%). The SSH sector is the only one that considers the experimental activity remotely or via streaming: this could be consistent with the conduct of qualitative interviews at a distance.

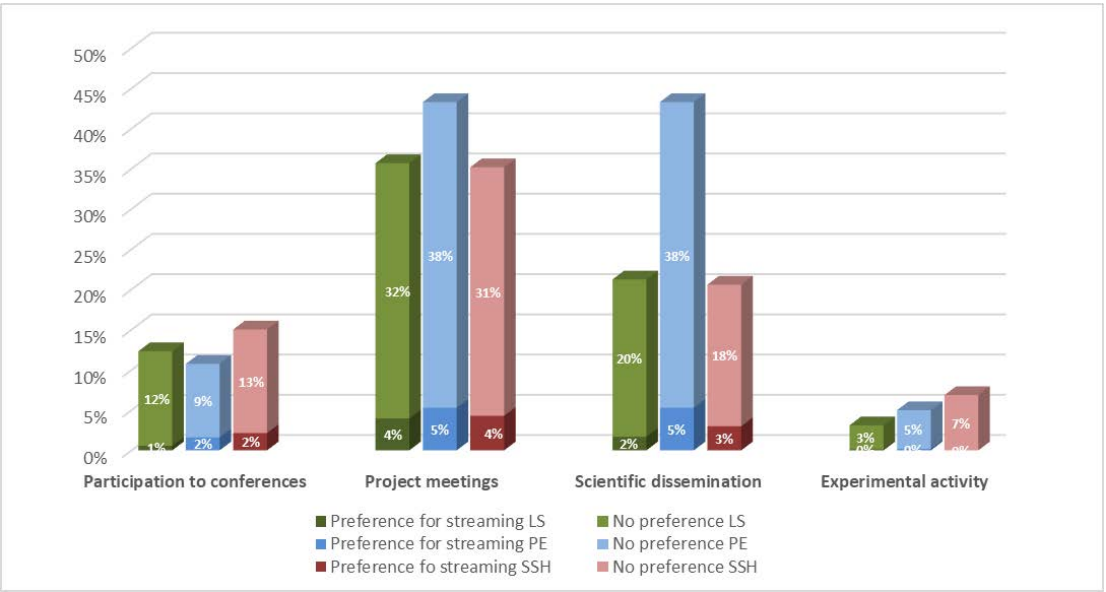

Figure 6.3. Respondents who preferred (before the COVID-19 emergency) to carry out some research activities in streaming mode instead of in presence or did not have specific preference between streaming mode and "in-presence" mode. Percentages of total respondents by ERC sector.

5.2. Introduction to remote work and availability of ICT tools and services

The health emergency prevented all personnel from CNR research institutes and INAF personnel who had not previously experimented with agile working[9] from being gradually introduced to the new working mode through courses or initiatives that would have facilitated adaptation to remote work, particularly in terms of the use of ICT resources appropriate to the specific needs.

Figure 6.4 shows that three out of five respondents undertook agile working without prior training on the ICT resources proposed by their organization, and neither they were interested in attending one on their own initiative. Only 5.1% of respondents reported that their institute/organization provided one or more specific online training sessions for the use of certain services or tools (14.2% of INAF respondents and 3.7% of CNR respondents). The indication of a webpage dedicated to agile working with a list of tools and services emerged in about 7% of responses, and 5.6% of respondents attended courses on their own initiative. Finally, it is interesting that 23% of respondents did not want to inquire about training activities eventually proposed from their institute/organization and reported that they did not know whether their organization offered courses or seminars on ICT tools and services.

[9] Before the COVID-19 pandemic emergency, INAF was already experimenting with agile working (see Reale etal., 2020) so that 23 respondents had prior experience with agile working.

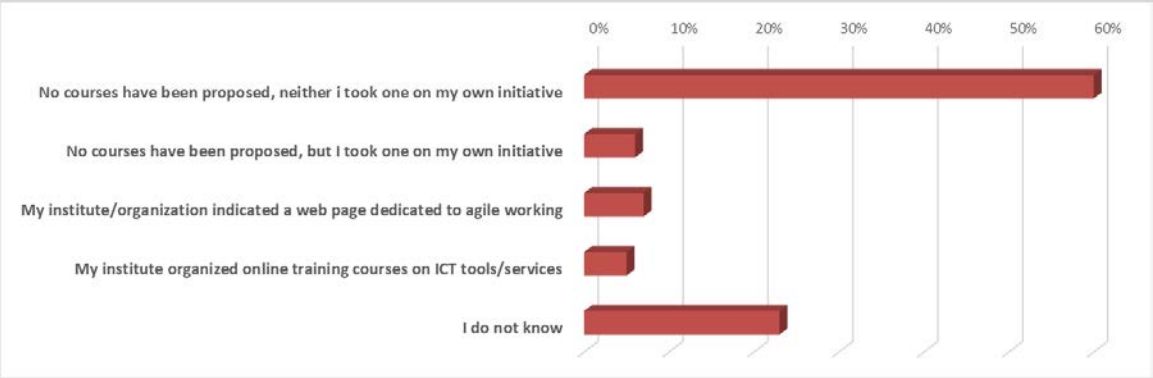

Figure 6.4. "Has your institution/research institute offered you training to introduce you to ICT services and tools useful for carrying out agile working?" Percentages of total respondents.

Given that most of the research personnel were unable (or unwilling) to receive training on ICT tools and services for performing agile working, what is their level knowledge on some of them? Figure 6.5 summarizes data on those who have reported an absolute lack of knowledge about selected services or tools[10]. Among the lesser-known services are the "use of remote servers for the use of specific software" (38.4%) and the "remote IT support" (35.3%). These services are more unfamiliar for the respondents from the age cohort 44-54. Also noteworthy is the percentage of those who reported ignorance of the VPN/proxy server service (27%), with a large incidence for the older age cohort, and the cloud spaces of the organization to which they belong, if available (23.4%). On the other hand, the percentage of people who are unfamiliar with chat programs and audio/video conferencing programs is very small. Generally, the weights between different cohorts are not remarkable.

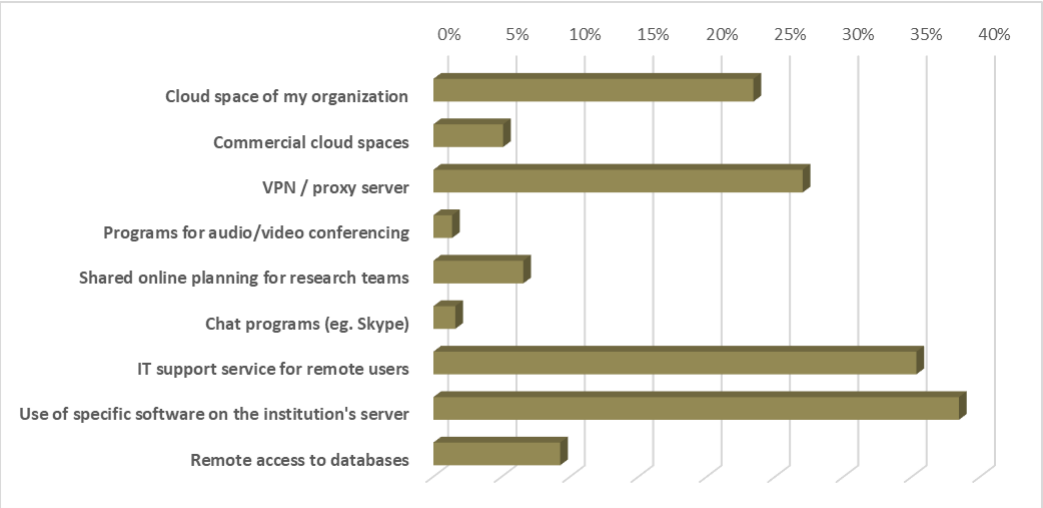

Figure 6.5. Lack of knowledge of ICT services/tools. Percentages of total respondents.

[10] It should be specified that the survey presented the option of lack of knowledge as an alternative to the "availability, but no use" or "availability and use (at different intensities)", so the answer "I don't know this tool/service" must be considered free of the availability bias in the specific organization/research institute seats.

Moving to the actual availability of ICT tools and services, it is interesting to understand how much the research personnel could have access to them from the institute/organization.

Table 6.3 summarizes the percentage of respondents who stated they would use certain ICT tools or services because they know their potential for work, but they are not available at their workplace or provided by their institute/organization. It was discovered that 14% of respondents reported the unavailability of a cloud service provided by their organization, while 12% expressed dissatisfaction about the unavailability to obtain specific software for use on the institution's servers. Low percentages were found regarding the unavailability of VPN/proxy servers (7% of respondents reported it) and IT support services for remote users (8%). As regards the first service, the territorial element acquires a more marked importance for respondents from the North-West (11%), whereas the provision of help-desk structures is less frequent in the Center (10%). The percentage of those who cannot obtain remote access to databases is limited. Overall, the IT equipment made available to the research staff appears satisfactory and net of some shortcomings, and the territorial differences do not appear particularly significant.

Table 6.3. Impossibility of using some ICT tools/services because of unavailability at the workplace: territorial differences. Percentages of respondents who reported knowledge of the tool/service

	North-West	***North-East***	***Center***	***South and Islands***	***Total***
Cloud space of my organization	12	14	16	15	**14**
Use of specific software on the institution's server	14	11	10	13	**12**
IT support service for remote users	7	6	10	7	**8**
VPN / proxy server	11	5	7	7	**7**
Remote access to databases	2	2	2	4	**3**

In any case, the ability of the research personnel to be adequately trained and equipped in terms of ICT tools or services comes second to the ability to have a reliable and fast home connection, which constitutes the necessary requirement for carrying out many of the activities in agile working, ranging from communication with colleagues to the ability to access bibliographic resources or virtually access network resources in the office via VPN.

As shown in Figure 6.6, while more than half of respondents have an ADSL connection via fiber (58.5%) and nearly another quarter have one via cable, 18.5% do not have either one or the other at home (Figure 6.6). This percentage of respondents relies on a smartphone hotspot (8.5%), an independent SIM card (4.3%), or ADSL via antenna (5.9%). Overall, subscriptions to internet service providers (Figure 6.7) are “flat” type (93.2%); however, in a small number of cases, the connection provides pay-as-you-go rates (6.8%). As a result, the situation related to the type of internet connection and subscription is not uniform among respondents, and for a portion – albeit limited – of the workers it can result in an increase in costs and potential difficulties with connection stability.

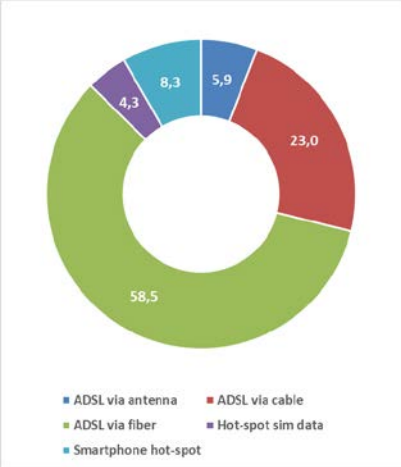

Figure 6.6. "What kind of internet connection do you mainly use for your agile working?" Percentages of total respondents.

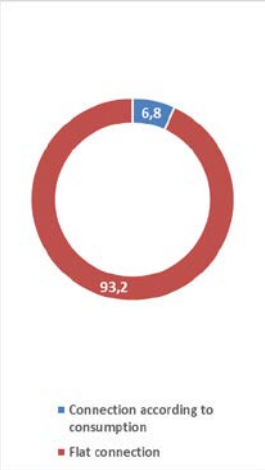

Figure 6.7. "Which type of subscription do you use for your internet connection?" Percentages of total respondents.

5.3. Use experience and potential for the transformative role of ICT services and tools

A scale of use experience was needed to understand the actual utilization of the ICT resources experienced by research personnel during agile working, as well as their potentially transformative role in work organization. Within the survey, the following scale was created for each ICT service/tool, with the respective coefficients (reported in brackets) being used to calculate their potential to have a transformative role in terms of work organization:

"I did not use [the service/tool] during agile working" (0);
"I have used [the service/tool] in agile working *to the same extent as* when I'm at office" (0.25);
"I have used [the service/tool] in agile working *more* than I usually do at office" (0.75);
"I have been using [the service/tool] *since I am in agile working*" (1).

The intensity of use of each service/tool is calculated by adding the percentages of respondents who chose options that admitted both the availability and use of the service/tool; the weighted sum of the above percentages, taking into account the coefficients associated with each response option, yields the scores of transformative power.

When looking at the data (Figure 6.8), it's clear that some services were used more than others and that each has a different potential for transformation in the organization of work. The expansion of use of audio/video conferencing programs, which were employed by 96% of respondents, is particularly significant: 30.1% of respondents were already using them, whereas 28,4% of respondents first used them in agile working. The use of these programs increased in 37.5% of cases when compared to office use, and this translates to a high level of transformative power (64). Chat programs were widely used by 96.7% of respondents, with 33.7% increasing their intensity of use and 8.5% using them for the first time. They show a score of transformative power (47), which is high but noticeably lower than audio/video conferencing programs, mainly because of an expanded use already prior to the agile working period (54,5%). Shared online planning (score 41) was largely used during the agile working period (89.1%) and had an appreciable increase (17.4%) and a noteworthy percentage of first use (11.9%). The score in the transformative index is 40, just below the percentage of chat programs.

A separate consideration must be made for the use of the VPN/proxy server (used by 55.1% of respondents), which was not commonly used prior to the COVID-19 emergency (only 4 out of 10 respondents used it), resulting in the second highest percentage of first uses among the ICT services/tools proposed (15.2%) and an increase in 15.4% of cases. The latter percentages produce a good transformative score for this service (33). The data show that it moved away from its previous ancillary role, but also signal a reliance on outdated technology to access files or software located at the office. The data must be read in parallel with the one on "specific software on the institution's server", a more efficient and less expensive service that allows operations to be run remotely without the use of VPN networks. This option was used by 45.1% of respondents before the pandemic, and a greater use and a first use of agile working were reported by 4.3% and 4.5% of respondents, respectively.

With almost the same score as the VPN, commercial cloud spaces (score 32) and remote access to databases (score 31) had a high intensity of use (88.7% and 84.7%) but proportionally a lower transformative power, as they were used in agile working to the same extent as at the office by 72% and 68% of respondents.

The score of the IT support service for remote users (26) is affected by the low percentage of respondents who knew about this service (see Figure 6.5), but 1 in 10 respondents were able to use it for the first time, and it was used by 52.9% of respondents overall. Finally, internal cloud spaces, used by less than half of the respondents, scored marginal scores in the "transformative" index (17), probably because of the unavailability in many locations (see Table 6.3) and the preference for commercial services.

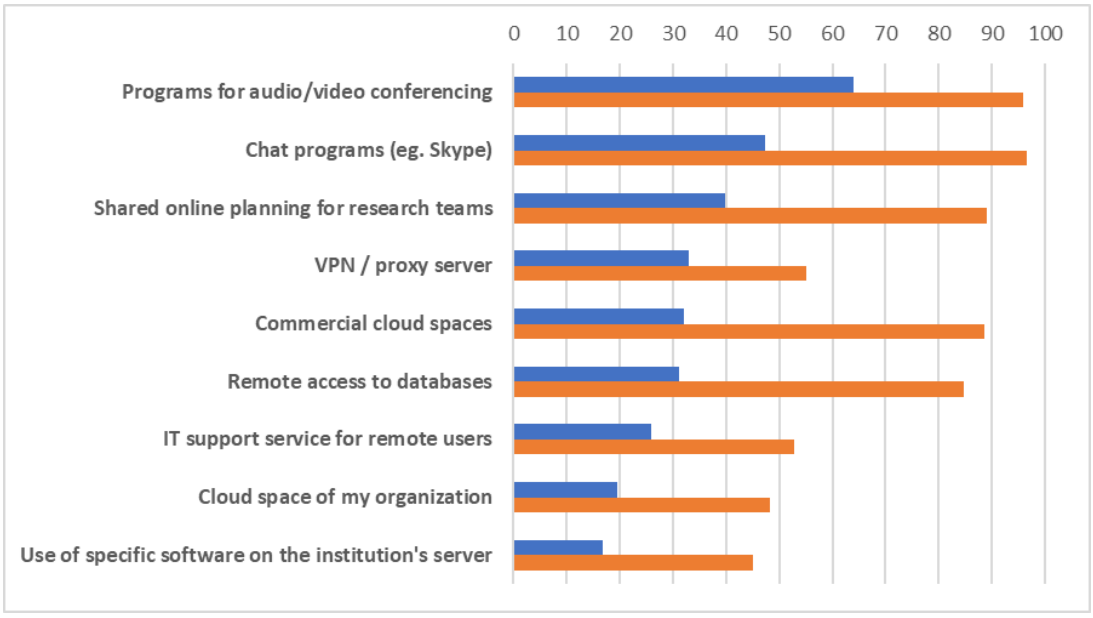

Figure 6.8. User experience of ICT tools or services in agile working. Survey question: "Have you ever used the following ICT tools/services and if so, how much has their use changed with agile working?". Note. In blue: the index of transformative power for each ICT tool/service (score 0-100); in orange: the percentages of respondents who used tools/services in agile working.

To delve deeper into the use of ICT tools/services experienced by respondents from the various ERC sectors, the percentages reported by the two modalities "I have been using it *since I am in agile working*" and "I use it in agile mode *more than at office*" were combined (Figure 6.9).

Audio/video conferencing programs, chat programs and shared online planning for research teams all show a cross-sector increase in usage. This trend is slightly more pronounced in the SSH sector, where the first uses are numerous (especially for the first tool), and slightly less

pronounced in the other sectors. The PE sector is strongly distinguished by the first use or the increased use of VPN/proxy servers (18.4% and 18.8%), even doubling about the percentages reported by the other sectors. As for the commercial cloud spaces, SSH showed greater increased use compared to LS and PE. IT support service for remote users presents a comparable (and low) experience of first or increased use for every sector, with a higher propensity of use for hard sciences. The first or increased use of specific software achieves noteworthy percentages in the SSH sector (6% and 7.3%), which also increases remote access to databases (14.6%).

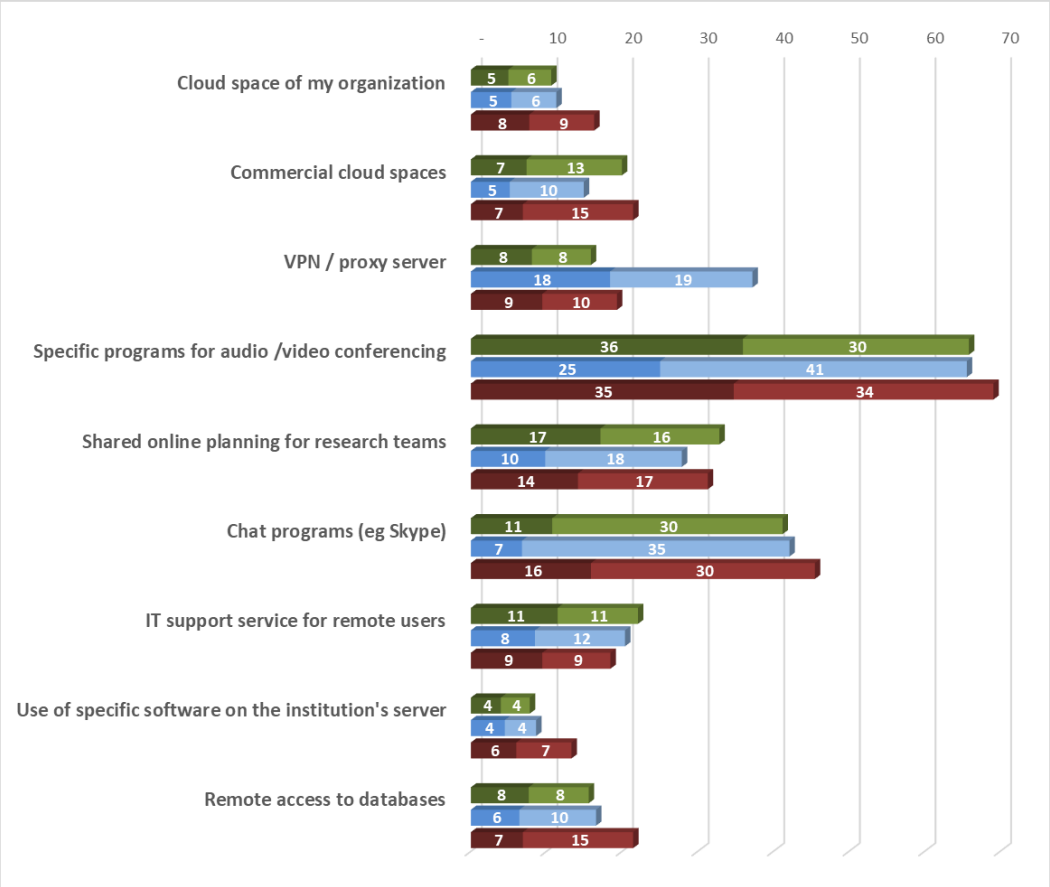

Figure 6.9. Early use (soft color) and increased use (strong color) of services/tools in agile working. Percentages of total respondents by ERC sector. Green = LS; Blue = PE; Red= SSH.

In the case of ICT tools/services that have demonstrated a greater potential for transforming the organization of work for research personnel, breakdowns by age cohort and gender revealed overall a more marked transformative role for the oldest cohort and for women (Table 6.4).

When it comes to audio/video conferencing, chat programs and shared online planning for research teams, the oldest cohort (over 55) has the highest percentage of early adopters (30.8%, 11.1%, 13.4%). The 30-44 and 45-54 cohorts have similar values in terms of tool/service use, with more early adoptions in the latter and a more increased use in the first, attesting to uses that have already been embedded into the habits of the younger cohort. Once again, a separate discussion must be dedicated to VPN/proxy servers, a service that the older cohort does not use frequently and that the younger cohort experimented for the first time in a remarkable number of cases (17.6%).

As for the gender, women significantly increased the use of programs for audio/video conferencing and shared online planning compared to men (respectively 70.2% vs 61.9%, and 32% vs 26.8%) with a greater incidence of early adopters, while men increased the use of

VPN/proxy servers (33.1% vs 28.3%) for which lack of knowledge and non-use are more marked in the female population (43.5% vs 35.5%).

Table 6.4. Use of selected ICT tools or services. Percentages of total respondents by age cohort and gender

	Don't use the tool / service	Early use in agile working	Increased use in agile working
Programs for audio/video conferencing			
30-44	2.2	26.1	41.3
45-54	2.4	28.6	36.9
Over 55	3.2	30.8	34.1
Female	2.3	34.6	35.6
Male	2.8	22.7	39.2
Shared online planning for research teams			
30-44	6.5	10.5	19.0
45-54	8.3	12.1	18.1
Over 55	13.5	13.4	14.8
Female	8.7	14.9	17.1
Male	9.6	9.0	17.8

	Don't use the tool / service	Early use in agile working	Increased use in agile working
Chat programs			
30-44	1.5	6.2	36.4
45-54	2.1	8.3	34.8
Over 55	4.8	11.1	29.5
Female	1.9	10.0	33.3
Male	3.3	7.0	34.2
VPN / proxy server			
30-44	34.4	17.6	18.5
45-54	38.7	14.4	15.7
Over 55	46.0	13.6	11.8
Female	43.5	14.2	14.1
Male	35.5	16.3	16.7

How much experience with ICT tools/services gained during agile working has been translated into an ICT skill empowerment? When respondents were asked which were the top three benefits of agile working, ICT skills improvement was the least chosen option (see Chapter 3): only 5% of respondents reported a remarkable empowerment, which is stronger for women than for men (7% vs 3%). As age increases, however, it is possible to see a higher percentage of respondents reporting benefits in acquiring new ICT skills: from 3% of respondents from the 30-44 cohort to 7% of respondents over 55 (Figure 6.10). As for the ERC sector, the percentage of SSH respondents (10.3%) was quite significant.

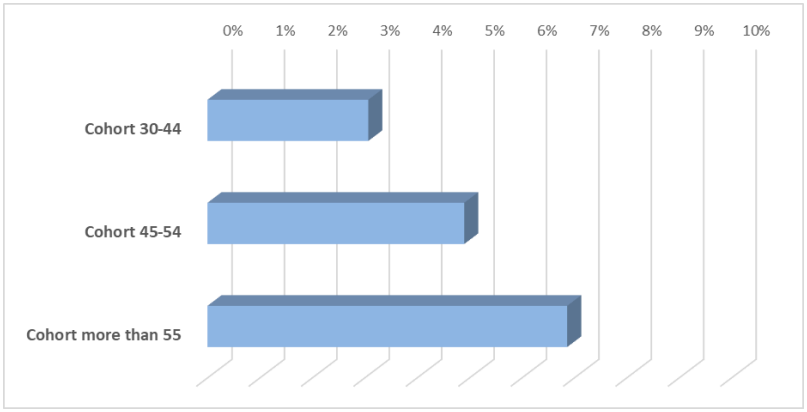

Figure 6.10. Percentage of respondents who indicated an empowerment in ICT skills by age cohort.

5.4. Technical limitations and difficulties

The survey included questions to determine whether research personnel experienced technical problems or other issues while utilizing ICT services and tools in agile working, revealing a difficult adaptation to new working conditions for performing activities. As shown in Figure 6.11, in terms of technical issues, slightly more than half of respondents (51%) reported they had none. Instead, the remaining respondents reported one or more technical problems.

The most recurring problem was related to internet connection, and it affected a third of the interviewees. In the free comments, some respondents complained that the bandwidth of the home connection was lower than that of the office, slowing down data transfers and communications; others reported about their choice for a powerful connection subscribed at their own expenses. Therefore, the instability of the connection has been reported frequently and this is combined with the fact that many respondents do not have a fast connection via fiber or cable (Par. 5.2). In particular, the bandwidth for one of the most used tools, videoconferencing programs, often appeared insufficient for good use (25.9%).

Another issue was the lack of computer processing power (reported by 12.8% of respondents), while the inability to access databases and the lack of functioning of VPN/proxy servers was complained by 7.2% and 6.6% of respondents, respectively. Bad functioning of cloud services (2.7%) was reported to a limited extent.

Other non-technical difficulties were the inability to print due to lack of personal printer (34.1%) and the inability to use multiple computer screens (18.2%). Regarding the last aspect, in the free comments, reference is often made to the small size of the unique monitor.

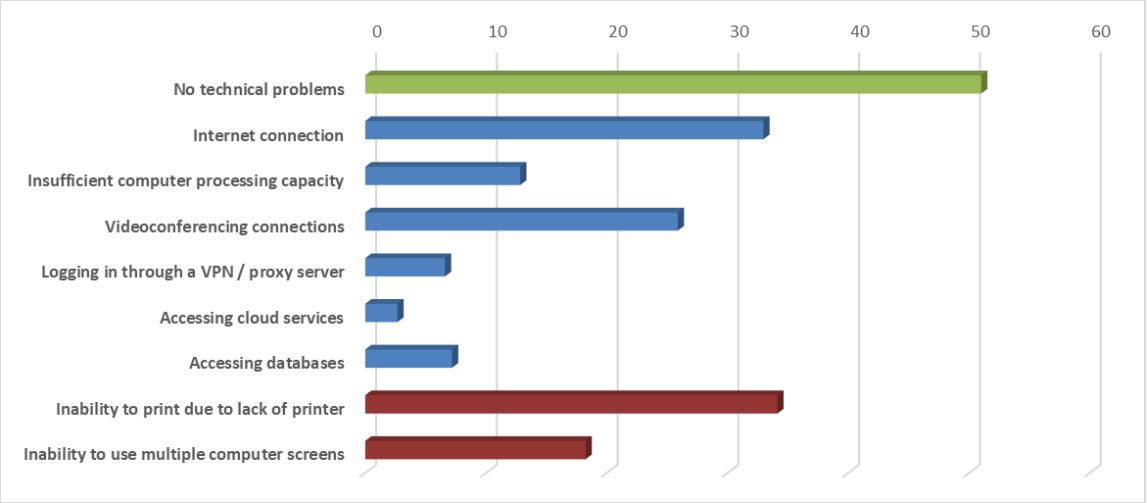

Figure 6.11. Technical problems and other difficulties in performing agile working. Percentages of total respondents.

Some of the issues raised by the respondents were further investigated to see if they were more prevalent in respondents from certain macro sectors than others. As shown in Table 6.5, the inability to use multiple computer screens has a higher number of negative reporting from the PE sector (20.9%), while the difficulty in accessing databases is higher for LS and SSH than for PE.

Table 6.5. Specific problems encountered by respondents during agile working. Percentages of total respondents by ERC sector

	LS	PE	SSH
Insufficient computer processing capacity	13.0	12.8	12.9
Accessing databases	9.2	6.2	9.4
Inability to use multiple computer screens	12.5	20.9	18.2

The presence of technical issues during agile working could have negatively influenced the research personnel productivity. To verify this aspect, the percentage of respondents who reported a decrease in productivity, as measured by the production of papers/monographs, was calculated on the total number of respondents who encountered specific technical problems. The percentages by type of issue are generally not particularly high, as shown in Table 6.6, but they are worth noting. A decrease in productivity, combined with an insufficient computer processing capacity, was reported by almost the same proportion of respondents from the three ERC sectors, with PE slightly prevailing (15.8%). A diminution in productivity was experimented by 17.9% of LS respondents, who reported difficulties in accessing cloud services, and by 16.3% of PE respondents and 13.6% of SSH respondents, who reported issues in accessing databases. Among those who reported issues in the process of logging in via a VPN/proxy server, a decrease in productivity was complained more by PE respondents (12.2%) than LS and SSH respondents.

Table 6.6. Percentages of respondents who reported a diminution of scientific productivity while experiencing specific technical problems in agile working, by ERC sector

	LS	PE	SSH
Internet connection	10.5	12.3	11.3
Insufficient computer processing capacity	13.0	15.8	13.3
Videoconferencing connections	12.0	13.3	13.0
Logging in through a VPN / proxy server	6.3	12.2	7.7
Accessing cloud services	17.9	9.8	11.1
Accessing databases	9.2	16.3	13.6

6. CONCLUSIONS

Because of the COVID-19 pandemic, the implementation of agile working occurred abruptly, forcing the PRO research personnel to experiment a new mode of working for which ICTs are both necessary enablers of organizational change and essential elements for operability. Throughout their experience, research personnel relied mostly on their prior experience with ICT tools and a set of technological services that had been set up quickly and not homogeneously by their respective organizations. Among the public administrations, non-economic bodies including PROs are lagging in providing their employees with adequate equipment for remote work, including hardware and software, and they are characterized by a limited investment in the training targeted to new working practices. Given these factors, data from the survey revealed a significant commitment by research personnel to autonomously adapt to the sudden transformation of working methods based on a massive use of ICTs, particularly among the older age cohorts.

Even in ordinary times, the option of conducting research activities without the office equipment has often been considered by research personnel (above all from the younger age cohorts and with some differences between the ERC sectors), and this has undoubtedly given an advantage in adapting to the use of ICT resources for research activities. The implementation of agile working has therefore forced to intensify the use of some previously experimented ICTs tools and services, while also fostering the early use of new ones. A strong increase in the adoption of audio/videoconferencing programs emerged as a result of the need of holding conferences and project meetings in remote connection. In addition, there has been an increase in the use of chat programs to facilitate communication and collaboration with colleagues. A critical issue concerned the lack of comprehensive training on the various ICTs resources for agile working, which resulted in a lack of awareness of the existence of certain services. In this regard, the use of VPN network was preferred to other technological solutions such as the use of specific software on the institution's server (when available).

The early or intensified use of some ICT tools and services during the emergency can only be partially understood in the terms of the concept of performance expectancy (Venkatesh et al., 2003, see Par. 3). The decision to use some tools over others appears more related to three main factors: the conditions of contingent need; the availability of the tool/service; the awareness of the user. Compared to other ICTs, communication tools and systems to connect to external network have been shown to have an appreciable degree of transformative potential in the organization of work, with the first having a transversal importance across respondents from all the ERC sectors and the latter being more oriented towards the PE sector.

While half of the respondents reported no technical issues with ICTs while performing agile working, it should be noted that the research personnel's personal equipment was not always sufficient to ensure that the work could be carried out without any problem. Particularly, the expanded use of programs for audio/video conferencing produced the major technical difficulties, in many cases due to the characteristics of the internet connection available at home. The presence of specific technical issues could have had some effect on the research personnel productivity, but this aspect requires further and targeted investigations.

Leveraging the experience gained from agile working implemented in emergency, research personnel could take advantage of new ways of performing research activities based on an expanded use of ICTs. In general, research work can be regarded as a fertile ground for experimentation with managing activities associated with the use of new technologies, because it is intrinsically characterized by a high level of flexibility and adaptation to innovations (see National Academy of Sciences, 1989; Borgman, 2007; Arcila-Calderón et al., 2015). Nonetheless, organizations must help by putting more effort through training, communication and the provision of a variety of useful tools and services for remote work.

The rapid transition towards formats of work conducted from remote should be seen as an opportunity to catch up with the innovations required and envisaged by the PNRR (Recovery and Resilience Plan)[11] adapting structures and working methods to the demands of an increasingly digital-oriented knowledge society. The push towards digitalization in scientific institutions, ambivalent and discontinuous in the past decades, can now be re-thought with a view to making investments aimed at innovating knowledge production processes and a greater use of technological tools. Furthermore, this would allow to realize even more completely the flexibility and autonomy that have always been considered the fulcrum of the quality of research activity and a right for the researcher, as well expressed by the European Researchers' Charter according to which:

> Employers and/or funders should ensure that the working conditions for researchers, including for disabled researchers, provide where appropriate the flexibility deemed essential for successful research performance in accordance with existing national legislation and with national or sectoral collective-bargaining agreements. They should aim to provide working conditions which allow both women and men researchers to combine family and work, children and career. Particular attention should be paid,

[11] https://www.governo.it/sites/governo.it/files/PNRR.pdf

inter alia, to flexible working hours, part-time working, tele-working and sabbatical leave, as well as to the necessary financial and administrative provisions governing such arrangements[12].

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