Chapter 3
Individual autonomy and research creativity in time of COVID-19

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ABSTRACT
This chapter wants to shed light on the value of the autonomy in the organization of the individual work, with respect to the production of new scientific knowledge in non-university research institutions. The empirical base is the experience of smart working implemented in the Public Research Organizations (PROs) during the COVID-19 pandemic emergency, and the individual adaptation/reaction of the research personnel in two Italian PROs: the National Research Council (CNR) and the National Institute for Astrophysics (INAF). During the health-emergency period, scholars were required to work for most of the time at home, and several restrictions on free movement of people were imposed. The aim of this paper is to understand how this special condition influenced the activities of researchers and technologists and the production of original research work, thus impacting positively or negatively their creativity –namely, their attitudes of going beyond the exploitation of existing capabilities and routines.

KEYWORDS: smart working, research, creativity, research performance, autonomy.

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1. INTRODUCTION AND RESEARCH QUESTIONS

This chapter wants to shed light on the value of the autonomy in the organization of the individual work, with respect to the production of new scientific knowledge in non-university research institutions. The focus is on the experience of agile working implemented in the Public Research Organizations (PROs), and on the individual adaptation/reaction to these assets, which inform the autonomy of the scholar's behavior during the social containment measures deriving from the COVID-19 pandemic.

The observation refers to the effects of the special agile working that took place during the COVID-19 pandemic emergency in two Italian PROs, the National Research Council (CNR) and the National Institute for Astrophysics (INAF). During the health-emergency period, starting from March 2020, scholars were required to work most of the time at home, and several restrictions on free movement of people were imposed. The aim of this paper is to understand how this particular and extraordinary condition influenced the activities of researchers and technologists and the production of original research work, thus impacting positively or negatively their creativity – namely, their attitudes toward carrying out the scientific work even going beyond the exploitation of existing capabilities and routines.

Two main research questions drive the investigation: did the agile working during the COVID-19 pandemic affect the capability of the researchers to explore both already existing and new research questions/trajectories, and technologists' attitudes towards finding innovative ways of supporting the research activities? Was agile working during the pandemic a threat or an opportunity for knowledge creation?

The hypothesis we formulate starts from the consideration of the intrinsic characteristics of the scientific work carried out by the researchers (both scholars and creators of knowledge, following the Merton's types – Merton, 1973). The researchers' work is characterized by a strong dynamism, which arises from the curiosity to face new research questions or to find new solutions to ancient questions, through new investigation paths, new methods, new controls, and new theories. The research work, therefore, has a high degree of creativity and a natural tendency towards innovation; it represents the ground of choice for an organization that precisely enhances the characteristics of dynamism, flexibility, and adaptability to unforeseen events. Thus, we expect to find in the research institutions a work environment in which researchers and technologists have quickly adapted to the new working conditions, even if they have been extreme, quickly recovering the conditions of productivity and efficiency. This expectation is also in line with the part of the literature on smart working, which highlighted its advantages in the case of high creative industries (Chiaro et al., 2015; Leonardi & Bailey, 2008; Choudhury et al., 2021).

This chapter is divided into three sections: Section 2 discusses the researcher's work in terms of flexibility and innovation; Section 3 defines the dimensions analyzed in the chapter and the applied methods of analysis; Section 4 presents the analysis on preferences and on the work autonomy before the COVID-19 emergency, on the opinions about the smart working and on the attitudes towards the knowledge production and the research agenda during the COVID-19 emergency. At the very end, some concluding remarks are outlined, following the initial research questions and the operative hypothesis.

2. THE RESEARCHERS' WORK

Innovation is a key feature of the research profession (Shalley, 1995). The capacity to produce innovation in the scientific work is strongly related to the environment in which the researcher operates, its internal structures and processes; and the elements of the context can either trigger or constrain the innovation (Heinze et al., 2009).

Innovation in the research work can therefore be understood along three dimensions: innovation drivers (structures, processes, and contextual factors that help/hinder innovation), networking (the frequency of the communication outside the organization), and leadership (the qualities and capabilities of senior individuals within the organization) (Lewis et al., 2017). This chapter deepens the former and the second dimension with respect to the introduction of the agile working during the COVID-19 pandemic, to understand its relevance and its effects on the research work.

The analysis starts by considering some key features of the research work. Researchers are a special type of professionals that enjoy the freedom to manage their time and modes of knowledge production in a high flexible manner, changing and transforming them as needed, to adapt to new and unexpected events. According to Bourdieu, the scientist is «a man whose cognitive structures are homologous to the structure of the field and, thus, constantly adapted to the expectations inscribed in the field» (Bourdieu, 1984, p. 57). It is worth to recall that the research profession has as the most important and effective incentives the reputation and the prestige, which also produce direct positive effects on the organizations (Nicholas et al., 2015; Woolston, 2015; Origgi, 2016; Gonzalez-Sauri & Rossello, 2019). Thus, there are several elements to consider in the researcher's profession, which are likely to contribute to his scientific production: on the one hand, the relationship with the environment that has effects on the activities, including professional aspirations and motivations, and, on the other hand, the definition of the researcher and of his distinctive and specific characteristics, referring both to the professional and the personal level.

The outcomes deriving from the research work can, therefore, be a direct indicator of the work done (e.g., publications produced, projects managed, etc.), as well as an indirect indicator of the overall organizational context in which the research is produced. The level of satisfaction of the scholars refers not only to the results they achieve in terms of advancement of knowledge, but also to the level of organizational coordination and the possibility of making autonomous choices (Cannavò, 1989; Ziman, 1984).

The analyses in this chapter are intended to shed light on the inconveniences and the benefits in the organization of the individual work of non-academic research personnel who performed the smart working during the COVID-19 pandemic emergency period, with a particular attention on the importance of the autonomy for the research work, and the effect of this extraordinary condition on the scientific performance.

3. Dimensions of interest and methods

The empirical base comes from a questionnaire administered by CNR-IRCrES, targeted to detect perceptions and attitudes of researchers and technologists from CNR and INAF toward smart working implemented during the COVID-19 pandemic (Fabrizio et al., 2021; Fabrizio et al., § Chapter 2). The attitudes are related to actions or behaviors; therefore, they are the set of beliefs, ideas, values, and motivations that lead someone to action (Pickens, 2005). Perceptions are one's own feelings or opinions about something, which are based on sensory information and on the stimuli coming from the environment; they can shape the attitudes that in turn can be the foundations of the perceptions. Attitudes are associated with intentions and decisions. Attitudes and perceptions can be designed as a linear model towards decisions, or as components of more complex relationships, where there is not a transition from one component to another, but the mutual influence of different elements combining and re-combining to get different points of equilibrium over time (Fischer, 2017)

The data first depict some characteristics related to the spaces of autonomy inherent to the work in the Italian PROs during the ordinary time prior to the emergency; then they provide a picture of attitudes and perceptions on various dimensions related to (almost) uneven working patterns implemented in the emergency situation, including the repercussions that the smart working has had on intellectual performance. Finally, some evidence let us understand the

researchers' future vision, with reference to the possible application of agile working after the end of the emergency. Particularly, the questionnaire (see the Annex of this book) focuses on the possibility to choose the organizational modes that were most convenient before the COVID-19 emergency for performing the research activities (items C17, C19); on the perceptions about various dimensions of agile working i.e. associated with autonomy, efficiency and collaboration (D1, D9c); on the most relevant limits and advantages of the experienced agile working (D10, D11, D12); on the changes in the research performance between the pre-COVID period and the agile working period, with a special attention on the drafting of new papers and on the referee activity (D13a, D13f, D14); on the preferences about the implementation of agile working even after the COVID-19 emergency has finished (H1, H2, H3).

The analyses consider all the respondents from CNR and INAF who took part in the survey (2,921 respondents, of which 388 units from INAF and 2,533 units from CNR, see Chapter 2).

The breakdowns were based on the research domain[1] (mainly), the gender[2], the age cohorts, the type of research performed (experimental vs. non-experimental), the working position – researcher or technologist –, and on the presence of minor children at home. All the variables mentioned reflect critical items of both research profession and working under "special smart working conditions" (see Chapter 2). For categorical variables, the percentages were calculated using the denominator of the number of valid responses. In the analyses of the questions about perceptions and attitudes, the positive assessments are the sum of the two points on the positive side of a four-point Likert scale, whereas the negative assessments are the sum of the two points on the negative side.

Multiple Correspondence Analysis (MCA, see Di Franco, 2011) was used to investigate the pattern of the relationships between categorical variables describing the profiles of researchers/technologists expressing benefits and limitations related to the agile working performed during the emergency period. MCA allowed for pattern extrapolation across a group of variables described by single components; these components are referred to as latent unobserved variables that reflect the maximum variance of a set of other variables.

Free texts and comments to the open-ended questions were deepened using the traditional content analysis, reporting comments within coherent thematic classifications based on the experience of smart working in the emergency phase (D2 referred to D1), and on the benefits that might come from smart working in the future, when the pandemic emergency will be over (H3 referred to H1 and H2). The interpretation of the texts was developed under the hermeneutic approach, which has the aim of finding meaning in the written word. Since language provides both understanding (direct meanings) and knowledge (hidden meanings), the hermeneutic approach in the textual analysis emphasizes the sociocultural and historic influences on qualitative interpretation (Ricœur, 1976; Byrne, 2011).

[1] The disciplinary areas of the respondents were grouped into five research domains: Mathematics, Physics and Nature sciences (acronym MFNS, including 1 Mathematics and Informatics; 2 Physics; 3 Chemistry; 4 Earth Sciences); Life Sciences (LS, including 5 Biology; 6 Medicine; 7 Agricultural and Veterinary Sciences; Engineering sciences (ENG, including 8 Civil Engineering and Architecture; 9 Industrial and Information Engineering; Humanities (HUM, including 10 Antiquities, Philology, Literary Studies, Art History; 11 History, Philosophy, Pedagogy and Psychology); Social Sciences (SS, including 12 Law Studies; 13 Economics and Statistics; 14 Political and Social Sciences). It should be remembered that almost all the INAF respondents belong to the CUN 2 area (Physics), therefore to the MPNS research domain, while the CNR respondents are distributed over multiple research domains. In addition, different numbers of respondents refer to the identified research domains (1,643 from MPNS, 706 from LS, 339 from ENG, 126 from HUM and 107 from SS).

[2] 37 respondents did not indicate the gender and therefore were excluded from the analyses with a breakdown by gender.

4. ANALYSES

4.1. Work autonomy and work at office before the COVID-19 emergency

The COVID-19 pandemic imposed a flexible work organizational model, which included the spatial and temporal relocation of the tasks to be performed. Nevertheless, flexibility in work location and in the time of work are not novelty items for the research workers, but inherent aspects associated with the room of maneuver which characterizes the ordinary work of researchers and technologists (European Commission, 2011). Indeed, the Italian PROs are regulated by a specific contractual agreement that guarantees "the autonomous determination of the working time", and allows for different applications in various institutional contexts; this principle is accompanied, on the one hand, by the possibility of carrying out the work outside the office (e.g., in suitable places such as universities and libraries) using the institution of "self-certified off-site work", and on the other hand, by the researcher's autonomy in determining how to work in order to achieve the scientific and technological results specified in the annual program of activities.

In this regard, it is particularly interesting to investigate how far the research personnel from various research domains had exploited – prior to the onset of the COVID-19 pandemic – the possibilities associated with the self-determination of the autonomy space in terms of *where*, *when*, and *how* to carry out the work activity – which are the three elements of change that would have been influenced by the way they worked during the agile working period.

On a global level, the possibility to work off-side used to be exploited, at least partially, by one respondent out of two. Little more than half of the respondents stated that they did not believe they had the possibility to choose their preferred workplace during the ordinary working period before the emergency (51.8%), while a third stated that this option existed only in part (32.9%). The remaining 15.3% reported that they used to have complete control over where they work. As the respondents' ages increase, so does their possibility to choose their place of work autonomously totally or in part: while respondents in the 30-44 age cohort reported being able to decide autonomously for 41.2%, the respondents in the 45-54 age cohort reported so in 46.9% of cases, and those in the 55-65 age cohort in 56.6% of cases. The difference between the two different research organizations under examination is significant as regard to the choose of the option on having complete control: while the CNR respondents answered in the affirmative for 16.7%, those of the INAF did so only for 6.2%. The reason for not taking advantage of the opportunity to choose the workplace autonomously could be associated with negative indications from the management of the research institute/organization, but also with the peculiarities of the research domain to which the respondent belongs, for which the possibility of working in the office could be indispensable for obtaining research results.

Figure 3.1 therefore shows the differences between the various research domains. The respondents from HUM exploit most the possibility of choosing the preferred workplace (30% yes, 44% partly), and the SS also show greater possibilities (20% yes, 44% partly).

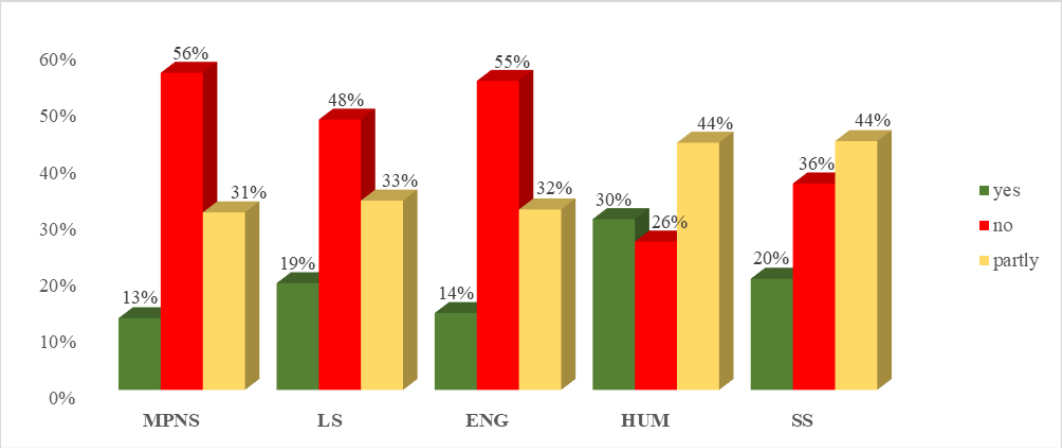

Figure 3.1. Possibility to choose the place of work autonomously before COVID-19 emergency. Breakdown by research domain. Total respondents: 2,921.

On the contrary, autonomously determining working time is a possibility that researchers and technologists have used more in their everyday activities before the emergency, fully or in part. Only 13.4% of all respondents reported they did not have the possibility to independently determine when performing the work, while 43.9% reported that they were used to choose, and 42.7% answered that this possibility already existed in part. The difference between age cohorts is not significant, although older cohorts indicate the affirmative option more frequently than younger cohorts. Furthermore, between CNR and INAF, as well as between researchers and technologists, there are no significant differences.

A greater autonomy on *how* to perform the work was reported by MPNS and LS (65% yes to the question) and by HUM (62%, with a very low percentage of full "no", with 2%). The SS shows higher percentages of respondents who indicated that it was not possible for them to choose the organizational mode of work they preferred (11%), but together with the ENG, they still show high percentages of respondents who answered "yes" or "partially" (89% and 92% respectively).

The respondents were asked about the preferred place of work for performing specific tasks, such as drafting papers or monographs, peer reviews, data analysis, literature consultation, and research project management during the ordinary work, before the COVID-19 emergency (Table 3.1).

The workplace chosen for the performance of the tasks is always the office, but with different importance: for the data processing and analysis (62%) and for the management of research projects (68%) it represents a place of absolute preference; while for the drafting of papers (41%) or monographs and for the peer review for scientific journals (34%) it does not represent an essential option. The first two activities are hardly carried out at home (10% and 4% respectively), while for the latter two the "at home" modality represents more than a quarter of the choices.

Table 3.1. Preference for the workplace for developing specific activities. Total respondents: 2,921

	At office	At home	In other places	Indifferent seat	Not applicable
Drafting of papers or scientific monographs	41%	26%	1%	26%	5%
Peer review for scientific journals	34%	28%	1%	29%	8%
Data processing and analysis	62%	10%	1%	23%	4%
Consultation of documents / literature	51%	14%	3%	29%	3%
Research project management	68%	4%	1%	21%	6%

Younger age group respondents are more likely to draft papers at home than the ones of the older cohorts (e.g., cohort 30-44: 29.3% vs. cohort 55-65: 23.4%); the same applies to the performing of reviewing activities (cohort 30-44: 30.3% vs. cohort 55-65: 24.9%). Living with minor children is not a determining factor in the choice of the work location, except for a slight preference for the office when it comes to drafting papers (49.2% of respondents living with minor children). Particularly interesting is that between 21% and 29% of the interviewees the location is completely indifferent. There were no significant differences regarding the choice of the "indifferent location" option among cohorts.

The data shows that the SS and the HUM are more accustomed to produce research outputs at home as far as the drafting phase is concerned, but also other scientific domains do not disdain this mode and do not see the office ad an essential workplace. Furthermore, there are no significant differences between living alone and living with others. Those living alone have a slightly higher preference for drafting papers or monographs at home (28.5% vs. 26.2%), while those living with others do not have specific preferences for this task (27%).

4.2. The general perceptions on agile working and the performance of the research work

When agile working became necessary for researchers and technologists because of the COVID-19 pandemic, it had to be implemented without significant organizational experience or a complete understanding of its complexities. The research organizations allowed for easy and extensive access to this mode of working: in the case of INAF, derogating from the regulation that accompanied the experimentation phase, whereas the CNR, which did not have a pre-existing disciplinary, established a transitional arrangement (Reale et al., 2020). Only a small fraction of the INAF's research staff had prior experience with agile working at the time of the emergency implementation, whereas all the CNR research personnel were in an unprecedented situation.

Agile working appears to be a positive experience for the research staff[3]. Indeed, analyzing the answers it is clear how the possibility of working from home, exclusively in a first stage of the health emergency and alternating with the presence in the office at a later stage, made it possible to manage work efficiently. Therefore, for many respondents, the opportunity/need to work from home represented an advantage that allowed the achievement of better working results:

[3] The survey gave the respondents the opportunity to reflect on agile working and express – through free spaces for comments – feelings and notes both on their experience and on the possible implementation of this method at the end of the COVID-19 emergency. The open-ended questions recorded a high participation by the respondents: for the first item, in fact, the answers were 564, one third of the total number of respondents; for the second (H3), the interviewees who gave their opinion were 2.080, almost all the respondents. Opinions and comments will be reported to highlight the empirical evidence through the respondents' own words.

> Having the possibility to mix the agile working with the face-to-face work allows for better work results in some scientific research activities. Many experimental activities are obviously linked to face-to-face work, but many others, such as data processing, bibliographic research, experiment discussion, research planning, writing scientific papers, the preparation and organization of seminars and conferences, the simulation of data, and the understanding of the results obtained, can also be done in agile working mode, achieving excellent results (Researcher CNR – Area 3 – Male).

The analysis of the comments gave a positive perception of agile working, with regard to the increase in productivity: this different way of working is profitable and advantageous for work performance:

> During this period of agile working, my work performance has improved considerably: I work much more but, at the same time, I can do many more things. I have expanded my contacts with other research groups, both national and international; I can concentrate much better on writing activities (articles, projects, presentation preparation); I can meet colleagues from other time zones and I have very encouraging concrete results (Researcher CNR – Area 11 – Female).

It is worth, therefore, to deepen the perceptions of research workers who have been suddenly introduced to a new way of working, different from the previous in several aspects, such as autonomy, efficiency, collaborations, and the reconciliation of work time and private life. In this regard, the interviewees were provided a battery of statements to test whether they agree with some general sentences about the new working condition or not (Figure 3.2 and 3.3).

With reference to the statement "It enhances the autonomy of work", the assessment of the respondents was largely positive. The aspects of freedom and autonomy would be even more emphasized by the agile working mode. Globally, 82% of respondents showed themselves to be "in agreement" or "very much in agreement" (where the latter modality affects about a third of the interviewees). The most enthusiastic about it were the researchers and technologists of the SS, who agreed for 88%, as well as those of HUM (87%); 83% of the workers from MPNS and ENG share the same opinion. A minor agreement comes from the respondents of the LS (76%), who for about a quarter expressed doubts about this statement.

When it comes to more specific aspects, such as work efficiency and collaborative work, the percentages tend to decrease slightly. The dimension of efficiency ("It promotes work efficiency") remains very high (HUM 79%, SS 76%, MPNS 70%). As to the collaborative work ("It is an opportunity for better organization of collaborative work"), no research domain reaches two thirds of sample.

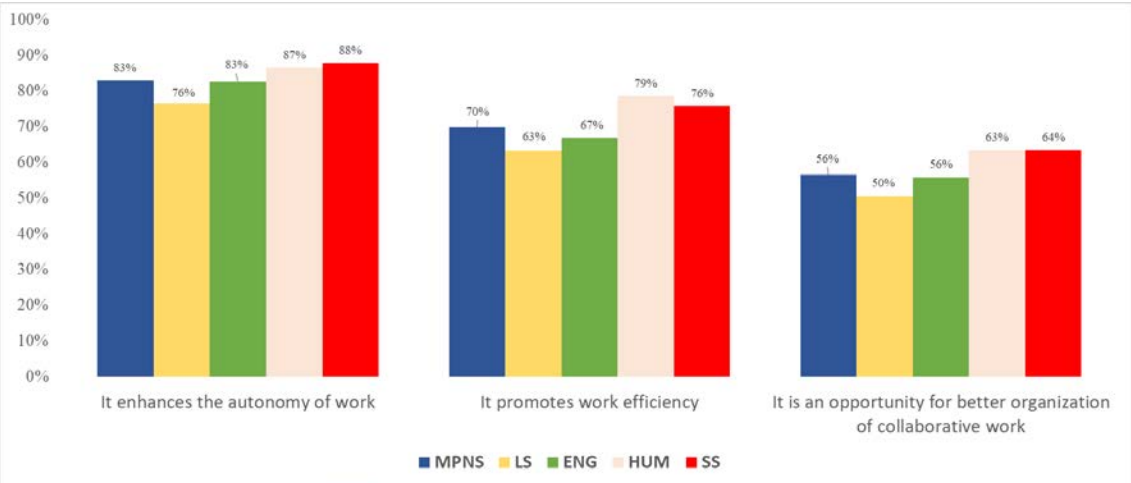

Figure 3.2. Agreement with some characteristics of agile working: autonomy, work efficiency, collaborative work. Breakdown by research domain. Total respondents: 2,921.

It is noteworthy that, regardless of the research domain, the level of enthusiasm for the opportunity of more autonomy, efficiency and collaboration brought by agile working is more intense for younger cohorts (about 83%, 71% and 57% respectively of positive reactions, both for the 30-44 and 45-54 age cohorts), and as age increases, this enthusiasm cools down (77%, 62% and 51% respectively for the 55-65 age cohort). Based on these data, according to a first impression, it is possible to infer – at least for most of the respondents – a general intrinsic predisposition of researchers to adapt without negative effects on efficiency and collaboration, enhancing the characteristics of autonomy connected to scientific work.

Figure 3.3 shows the level of agreement with the other two sentences proposed by the questionnaire. The first concerned the potential benefits of the agile working to reconcile working time and time spent on personal matters. Five out of five respondents said that "It is a way of working that allows to better reconcile work time and private life"[4]. The breakdown by disciplines does not present major differences, although once again the SS (86%) show a higher adhesion and the LS a lower one (76%).

As for the sentence "If not carefully regulated, it can have negative consequences", more than half of the respondents (57.1%) expressed fears about the possible negative consequences following the absence of a careful regulation of agile working. The main concern is expressed by social scientists (65%), while the other research domains have percentages ranging between 55% of MPNS and 61% of ENG. In this case, respondents living with children reported a stronger intensity of agreement with the sentence (45% of units living with minor children vs. 37% of units not living with minor children regarding the total approval). Surprisingly, the younger age cohort (30-44 years old, 61.8%) is the most concerned, compared to older age cohorts (45-54: 55.7%; 55-65: 53.3%).

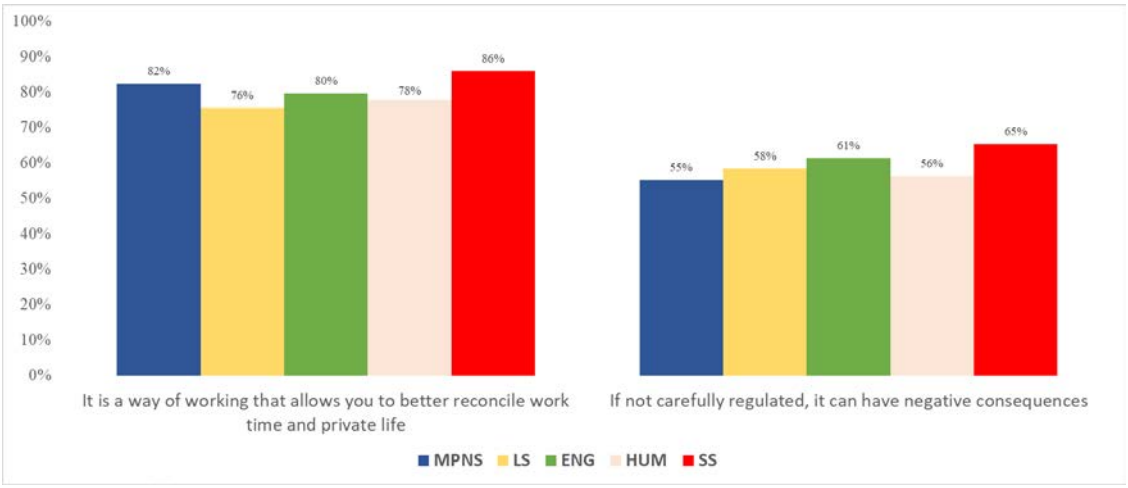

Figure 3.3. Agreement with some characteristics of agile working: reconciliation between work time and private life and eventual negative consequences. Breakdown by research domain. Total respondents: 2,921.

[4] If before pandemic it was almost impossible to be able to combine the different needs without any overlapping of times, now respondents believe that agile working can allow an optimization of times and a better organization of personal activities, whether they are work or family. This is evident from the responses of the respondents: "[agile working] allows for better family organization while also increasing family enjoyment. It reduces the amount of time spent commuting between home and work" (Researcher CNR – Area 1 – Female), or "It would enable me to better organize my family commitments and carry out my work more comfortably, with the proper balance of time spent in the office and at home" (Researcher INAF – Area 2 – Male).

Considering the previous data on the lesser agreement on the affirmation regarding agile working and collaborative work, it is advisable to check whether the results are confirmed by the degree of agreement on another questionnaire item, more focused on the general relational exchange: "Based on your experience of agile working during the COVID-19 emergency, does agile working compromise the relational exchange useful to the research work?" (Table 3.2).[5]

While a good percentage (59.5%) of the respondents disagree with the statement, thus denying negative consequences on relational exchanges, 40.5% manifest either an agreement or a strong agreement. The latter trend is most visible in the 55-65 age cohort (46.3%). The perceptions are therefore the same as the question on collaborative research. Fears about relational exchange are uniformly expressed through the research domains, slightly stronger for HUM than for the other domains. Scholars belonging to the SS consider agile working more favorably as a means that does not compromise the relational exchange, while researchers belonging to other domains follow in the same vein but more timidly.

Table 3.2. Opinions related to the sentence "Agile working compromises relational exchange useful to the research work". Breakdown by research domain. Total respondents: 2,921. Percentages

	Strongly disagree	**Disagree**	**Agree**	**Strongly agree**
MPNS	19.4	39.7	28.8	12.1
LS	22.2	37.0	28.3	12.5
ENG	19.5	40.4	26.8	13.3
HUM	20.6	40.5	23.8	15.1
SS	26.2	37.4	25.2	11.2
All domains	20.4	39.1	28.1	12.4

The element that emerges most from the scholars who decided to leave a free comment is the need for direct contact with colleagues which makes work more stimulating and effective. The absence of direct contact with colleagues represents a negative element of their experience, making work an alienating activity, especially for women.

> The direct scientific confrontation with co-workers in the workplace is irreplaceable and ensures maximum working efficiency. Synergies are formed in the presence of colleagues, which are difficult to achieve in agile working mode (Researcher CNR – Area 6 – Female).

> Agile working has many benefits, but the [contact with colleagues] must be done face-to-face because, by culture and habit, this is the most efficient way of exchanging ideas and coordinating efforts. The social aspect also helps to strengthen the relationships within the working group, which should not be overlooked. A balance is required (Technologist INAF – Area 2 – Female).

4.3. Disadvantages and advantages experienced during the agile working

The restrictions due to the pandemic compelled the researchers and technologists to achieve their work goals while being unable to dispose of office supplies and being separated from co-workers and superiors. Other circumstances at home (where most of the agile working has been done) may have affected the performances of researchers and technologists in various ways, making agile working somewhat difficult. These circumstances may include a wide range of

[5] The questionnaire item voluntarily presented a negative polarity pushing the interviewees to make an effort to reflect.

factors, such as the malfunction of internet connections, the presence at home of people to care for, the workspace inside the home, or the presence of annoying noises (Cellini et al., 2021; Menshikova et al., 2020). Still, some difficulties may be linked to personal peculiarities or to the psychological stress linked to the pandemic in progress (Tintori et al., 2021).

Respondents are almost equally divided into two groups: 49% affirmed the presence of unfavorable circumstances at home, while 51% reported their absence. No substantial difference was found regarding gender: 49.2% of female respondents and 48.6% of male respondents provided positive answers. Conversely, the presence of minor children at home has a strong role (63% of units living with children reported difficulties vs. 38% of units not living with minor children). The younger the age, the greater the likelihood of having experienced unfavorable circumstances to work from home (reported by 55% of the 30-44 cohort, 51.9% of the 45-54 cohort, but only 39.4% of the 55-65 cohort).

The differences can be noted depending on the disciplinary sectors (Figure 3.4), where the difficulties of not working in a laboratory or in the office can affect the respondents relating above all to ENG (54.3%), but also to MPNS (49.5% and LS 48.2%). HUM (38.9%) and SS (43.9%) reported fewer difficulties because working from home had caused less problems.

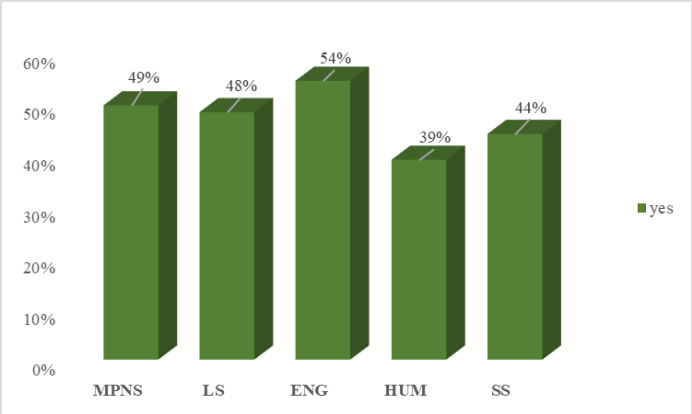

Figure 3.4. Presence of circumstances at home that make agile working difficult during COVID-19 emergency. Breakdown by research domain. Total respondents: 2,921.

The survey questionnaire deepened the most relevant disadvantages that were found by researchers and technologists in carrying out smart working during the emergency. Respondents were asked to choose up to 3 predefined options: in most cases, the interviewees selected three answers (37.9%), 28.2% of interviewees selected one answer, 34% two answers; and 3% of the interviewees did not indicate any disadvantages (Table 3.3).

Table 3.3. Number of disadvantages reported to the sentence "Agile working compromises relational exchange useful to the research work". Breakdown by research domain. Total respondents: 2,921

	N	%	Cumulative %
One disadvantages	823	28.2	28.2
Two disadvantages	992	34	62.1
Three disadvantages	1,106	37.9	100
Total	2,921	100	

The sense of isolation turned out to be the main concern with respect to the implementation of agile working (52%). From the perspective of work organization, more than a third of respondents felt that they were not able to clearly distinguish between the work time and the time dedicated to domestic and family care (37.5%) and the "work overload" (37%) . The increase in utility costs / internet connection was reported by 29% of the interviewees, while the reshaping of work calendars ("Postponement of deadlines and work activities") by 21%. The perception of a limited recognition of productivity represented a limitation for only 18% of respondents. A separate case is the option of excessive autonomy over activities which was reported only by 2% of survey participants, who said that having more autonomy represented a problem for them.

Apart from the most chosen option, there is no clear direction towards specific disadvantages, indicating a relatively accommodative reaction of the population under investigation regarding the extraordinary way of working. Figure 3.5 presents the data on disadvantages associated with agile working, showing that there are no significant differences between male and female respondents in the choice of options, except for the feeling of isolation, the one that had more choices, which affected more the female respondents than the male ones (55 % vs 49%).

In terms of age cohorts, the feeling of isolation was stronger for the 55-65 one (55.3%) than for the 30-44 (50.5%); the same applies to the feeling of work overload. On the contrary, the feeling of work fragmentation was felt more by younger respondents (45.8%). The latter limitation was mostly reported by units with minor children at home (56.5%).

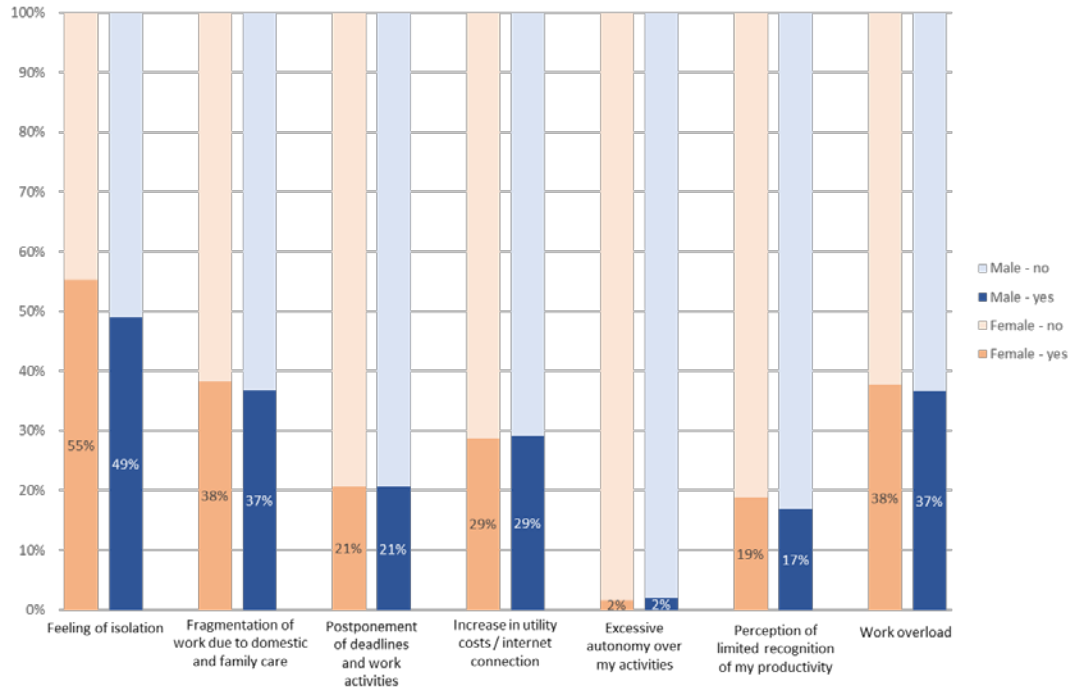

Figure 3.5. Disadvantages related to agile working during COVID-19 emergency. Breakdown by gender. Total respondents: 2,884.

No differences can be observed when comparing the respondents who carry out experimental research and those who carry out non-experimental research, except for two factors. Those who carry out experimental research have suffered most from the possibility of not being able to make a clear separation between working time and time dedicated to family care (39% vs. 35%), a circumstance that probably caused a fragmentation that was not useful neither to the work nor to the time devoted to oneself or to the family. Furthermore, the continuous changes in the work planning, probably due to delays in project deadlines, deliveries, or meetings, have caused greater inconvenience to those carrying out experimental activities (24% vs. 13%).

Following the reporting of the disadvantages of agile working, the interviewees were asked to identify the most important organizational and social advantages. Also in this case respondents had to choose up to 3 predefined options. The difference between the number of answers is more substantial in respect to what seen in the case of the disadvantages: 77.9% of the respondents selected three answers; only 0.7% of the interviewees did not indicate any advantages. Therefore, the advantages of the smart working have received a wider recognition between the respondents than the disadvantages.

Table 3.4. Number of advantages reported to the sentence "Agile working compromises relational exchange useful to the research work". Breakdown by research domain. Total respondents: 2,921.

	N	**%**	**Cumulative %**
One advantage	190	6,5	6.5
Two advantages	456	15.6	22.1
Three advantages	2,275	77.9	100
Total	2,921	100	

Figure 3.6 reports the most relevant benefits perceived by the respondents divided by gender. There are differences between female and male respondents in term of flexibility in time and mode of working (68% vs. 63%), increased productivity (22% vs. 26%) and the improvement of ICT skills, which is slightly more important for women than for men (7% vs 3%).

The perception of productivity is fully in line with other findings, which shows that although a percentage of both men and women experienced increased productivity during the pandemic period, the scale of growth was much higher for men than for women (Squazzoni et al., 2021; United Nations, 2020). This aspect is quite relevant, signaling the presence of trends towards inequalities and gender imbalances that affect also the research work, as happens in other less creative working environments.

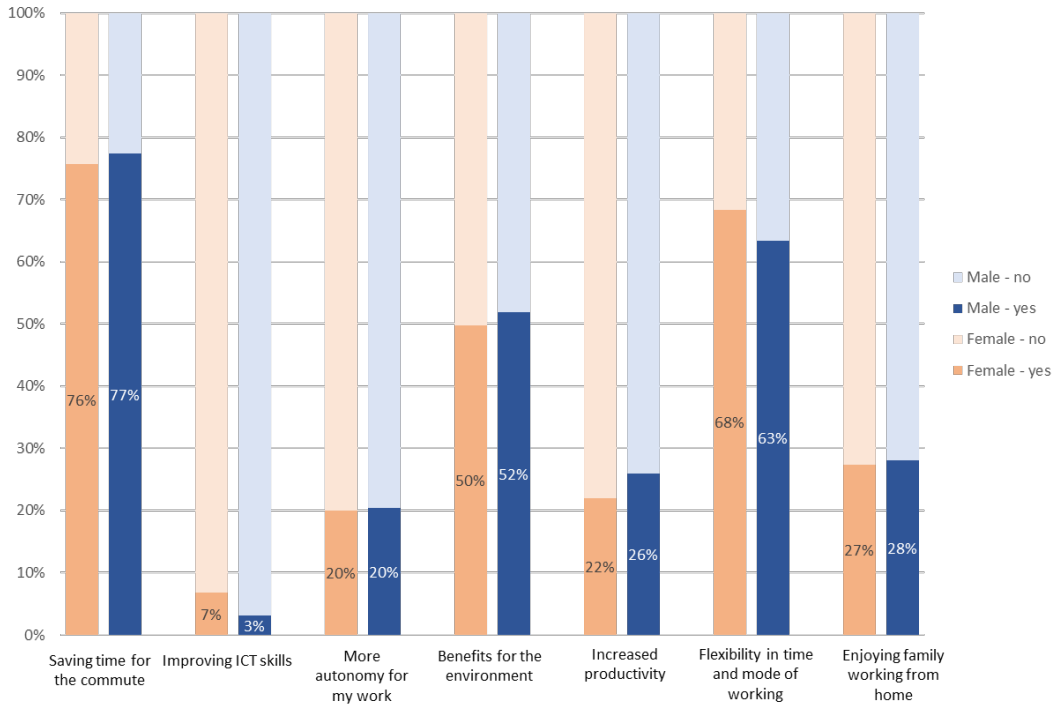

Figure 3.6. Advantages related to agile working during COVID-19 emergency. Breakdown by gender. Total respondents: 2,884.

To further analyze the relationships among the variables under consideration, we applied the Multiple Correspondence Analysis (MCA), which allows a combined analysis on the limits and advantages of the agile working. This analysis is based on the reduction of a set of variables into a reduced number of dimensions (factors) capable of reproducing and synthesizing the information contained in the original variables (see Di Franco, 2011). In this regard, the variables on the disadvantages and advantages related to the agile working[6] and to the structural variables (such as the gender and the disciplinary areas) have been used as active variables (the former) and illustrative variables (the latter).

The factors that summarize the original variables (Figure 3.7) show a distinction among disadvantages and advantages, in the first and second factor respectively. The first factor is characterized by the items related mostly to the disadvantages of the agile working. The positive axis is characterized by "Fragmentation of work due to domestic and family care" (.34), "Feeling of isolation" (score .23), "Postponement of deadlines and work activities" (score .18) and the "Excessive autonomy over my activities", thus referring to elements linked to the management and organization of respondents' work activities. The only exception is represented by the item "Enjoying family working from home", an element to be taken into consideration bearing in mind that the illustrative variables that contribute to the explanation of the first factor are the female gender and the belonging to biological and medical areas. The negative semi-axis, on the other hand, is characterized by elements such as "Improving ICT skills", "More autonomy for my work" and "Increased productivity", which refer to a positive perception of agile working; this

[6] The answers given to the category "other" – related to disadvantages and advantages related to agile working – have been separately analysed for both questions in the questionnaire. In the former case, this modality has been chosen by 507 respondents, whose answers, in most cases (310), could be linked to modalities already indicated in the questionnaire question, while, in other cases, they could be considered missing values. In addition, 197 interviewees indicate the "lack of adequate equipment" among the limits of agile working; for this reason, a new category was added to the ones already proposed. Concerning the advantages, the category "other" has been chosen by 72 people, but, differently from the disadvantages, all the answers, except for the missing values, could be linked to the potential advantages already suggested in the questionnaire.

axis is also characterized by structural characteristics, such as the male gender and the belonging to CUN areas like humanities and social sciences.

It is, therefore, evident that the first factor allows us to reflect on a different perception of agile working based on gender: female respondents refer more to the negative and the organizational aspects of work, while male respondents place the emphasis above positive aspects influenced by working from home.

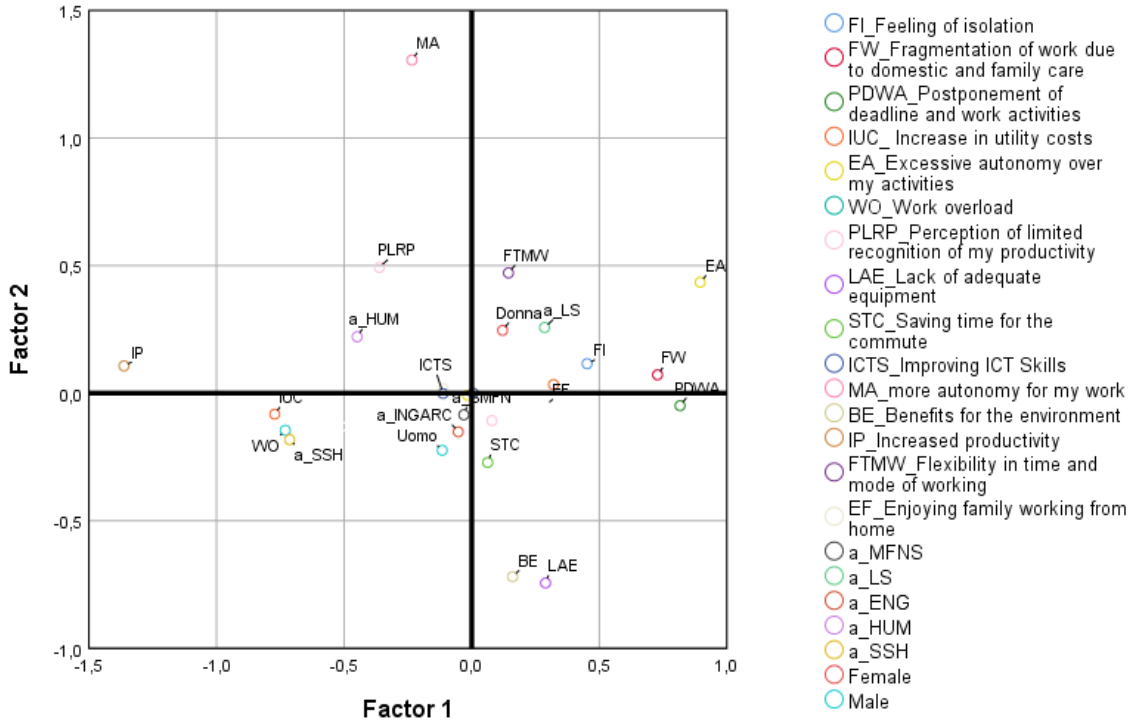

Figure 3.7. Active variables and illustrative variables on the factors extracted from the MCA.

The second factor refers to the advantages, especially on the positive semi-axis: on the one hand, on the positive axis, there are advantages such as “More autonomy for my work” (score .42), “Flexibility in time and mode of working” (score .42); on the other hand, the negative axis is characterized by the presence of some limits of agile working (“Postponement of deadlines and work activities”, “Increase in utility costs”, “Absence of instrumentation”). Figure 3.7 shows that being a woman and belonging to medical and biological areas contribute to the explanation of the positive semi-axes, while being a man and belonging to social science, engineering and architecture contribute to the explanation of the negative semi-axes. Therefore, gender and belonging to specific disciplinary areas are relevant characteristics associated with different perceptions of agile working.

4.4. Attitudes towards scientific performance

A section of the questionnaire compared the changes in the intellectual performance, operationalized through the variations in two peculiar research tasks – the production of papers/monographies and the development of peer reviews – between the pre-COVID period and the health-emergency period.

As mentioned above, the increased productivity has not been considered among the most important benefits of the agile working; nevertheless, through the analysis of data and comments it appears as one of the most promising aspects in the actual experience of the research personnel. Respondents' reports across all research domains point in the same direction: very few scholars experienced a decrease in the production of papers (8.9%), while nearly two-fifths reported an increase (38.4%) and 52.7% reported invariance between pre-COVID period and the agile working period. The breakdown for research domain (Table 3.5) yields a diversified pattern, with an impressive growth as regard to the drafting of papers affecting LS.

While more time spent at home has fostered creativity in terms of drafting research output, the peer review of scientific papers has not shown the same increase. The activity, already practiced by many at home (see Table 3.1), has remained substantially unchanged in quantity between the pre-COVID period and the agile working one. As Table 3.5 reports, once again, the LS reports a strong increase (32.7%).

Table 3.5. Variation of production of paper/monographies and developing of peer reviews in comparison between pre-COVID period and emergency period. Breakdown by research domain. Total respondents: 2,921. Percentages.

	Drafting of papers or scientific monographs		**Peer review for scientific journals**	
	Increased	*Stable*	*Increased*	*Stable*
MPNS	36.9	54.7	20.1	75.5
LS	45.9	46.5	32.7	64.2
ENG	31.3	54.9	24.8	67.6
HUM	38.9	52.4	15.9	77.0
SS	34.6	56.1	16.8	79.4
All domains	38.4	52.7	23.4	72.1

The presence of minor children at home is another important factor in comprehending the trend towards productivity (Table 3.6). In the context of a tendency towards invariance or an increase in drafting papers or monographs, those who do not have minor children at home benefit more from the increase than those who do (40.4% vs. 37.4%). This aspect, however, has no influence on the peer review activity.

Table 3.6. Variation of production of paper/monographies and developing of peer reviews in comparison between pre-COVID-19 period and emergency period. Breakdown by presence of minor children at home. Total respondents: 2,921. Percentages.

	Drafting of papers or scientific monographs		**Peer review for scientific journals**	
	Increased	*Stable*	*Increased*	*Stable*
Minor children at home - Yes	37.4	52.4	23.8	71.4
Minor children at home - No	40.4	52.6	23.3	72.6

Furthermore, age appears to be a relevant factor in relation to the increase in both drafting of papers and reviewing activity (Table 3.7): the younger the age, the higher the claim to increase productivity.

Table 3.7. Variation of production of paper/monographies and developing of peer reviews in comparison between pre-COVID period and emergency period. Breakdown by age cohort. Total respondents: 2,921. Percentages.

	Drafting of papers or scientific monographs		**Peer review for scientific journals**	
	Increased	*Stable*	*Increased*	*Stable*
Cohort 30-44 years	41.3	48.1	26.6	68.2
Cohort 45-54 years	39.1	54.1	24.7	71.2
Cohort 55-65 years	35.0	55.4	18.5	77.2
Cohort +65 years	23.9	63.0	17.4	78.3

Moving to other tasks performed by the research personnel, 43.7% of the research staff belonging to the MPNS and 51.6% of the ENG's one reported a shorter time dedicated to attending conferences (both physical and virtual). These domains also showed a more pronounced decrease in the commitment to scientific dissemination (29.2% from MPNS' respondents and 25.1% from ENG' respondents). A separate case is LS – a sort of outlier considering all the research tasks with reference to "hard sciences" – which has reported marked increases both in participation in conferences (even 49.9% of respondents) and in scientific dissemination (43.5%). In SS and HUM the increase in participation at conferences and web conferences was found to be quite impressive (54.2% for SS and 42.1% for HUM). Also noteworthy is the impulse towards scientific dissemination (reported increase of about 36.5% for both domains).

Among the aspects affecting changes in scientific production (Table 3.8), four out of five respondents reported that management's indications during the agile working period had no or little influence. The messages received from the management were given little weight, favoring autonomous conduct in scientific work. The logistics of the domestic spaces to be dedicated exclusively to the working activities had mostly limited effects, but it still affected almost 30% of the interviewees. The reorganization of working times and activities had a mostly positive impact, reflecting a good predisposition to adaptation, involving 2 out of 5 respondents (41.6%). Finally, the difficulty of carrying out some work activities due to not being able to use office resources and laboratory settings affected just over half of the interviewees (51.6%), and this may have had the positive effect of a greater concentration on the production of papers from unfinished or recently completed works.

Concerning the last point ("The difficulty of carrying out some work activities"), it is precisely the research staff engaged in experimental research who reports a higher level of difficulty than those engaged in non-experimental activities: a lot, 25.7% vs. 9.1%; enough ,34.2% vs. 25.8%.

Table 3.8. Aspects affecting the changes in scientific production during the emergency period. Total respondents: 2,921. Percentages.

	Not at all/A little	Enough/A lot
Specific indications received from the management	80.0	20.0
The logistics of domestic spaces to be dedicated exclusively to working activities	70.8	29.2
The reorganization of working times and activities	58.4	41.6
The difficulty of carrying out some work activities	48.4	51.6

5. ATTITUDES TOWARD PERFORMING AGILE WORKING WHEN THE EMERGENCY IS OVER

The widespread activation of agile working during the emergency situations has challenged the traditional organization of individual work, with unavoidable implications for the future. Indeed, it is very likely that the ordinary working mode will shift towards more flexible models capable of balancing sustainability, productivity, and well-being, based on the lessons learned during the emergency. As a result, researchers and technologists can draw a first balance based on the agile working experience, weighing advantages and disadvantages and considering the adoption of a probable alternation between work at office and out-of-office.

When asked "Would you like to work in agile mode when the emergency is over?", 83% of the interviewees expressed themselves in favor, but with marked fluctuations regarding the cohorts, with less positive considerations among the cohort from 55 years old and over (Figure 3.8).

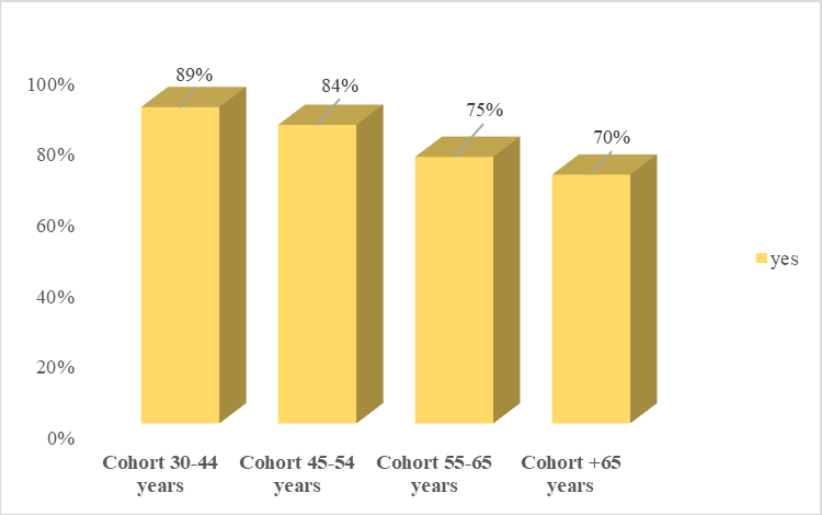

Figure 3.8. "Would you like to work in agile mode when the emergency is over?" Breakdown by age cohort. Total respondents: 2,921.

On the implementation of agile working after the pandemic COVID-19 emergency, many comments were very much in favour of maintaining the possibility to choose this working format, because it proved to improve the individual autonomy:

> I hope that after the pandemic phase, agile working will continue to be a freely selectable option alongside the more traditional vision of the 'office' working. The hope is that the worker will make the decision autonomously and in accordance with the established rules (Researcher CNR – Area 9 – Male).

> Agile working can be a resource that improves the autonomy of the researcher and increases the efficiency at work, also allowing the reconciliation of working times with private life, provided that the researcher can choose when and if to adopt it (Researcher CNR – Area 3 – Female).

Those who showed interest in performing agile working in ordinary time (out of emergency) were asked how many days per week they would like to spend in this working mode. Overall, the respondents preferred two days per week (average 2.5 days, median and mode 2 days). This figure was influenced by the number of respondents from various domains. In fact, SS and HUM prefer three days per week, while respondents from "hard sciences" prefer two (Table 3.9). Furthermore, this preference reinforces a greater compatibility with research activities developed in HUM and SS than in other fields, where however respondents would be willing to spend 40% of their working time in agile mode in any case.

Table 3.9. "How many days a week would you like to perform agile working?" Breakdown by research domain. Total respondents: 2,422.

	Mean	**Median**	**Mode**
MPNS	2.5	2	2
LS	2.3	2	2
ENG	2.6	2	2
HUM	3.2	3	3
SS	3.1	3	3
All domains	2.5	2	2

A final question, based on the interviewees' experiences, was asked to determine how much of the tasks can be effectively carried out in agile mode (Table 3.10). This item is a kind of control over the previous one. HUM and SS have very high percentages of respondents who believe they can perform almost all tasks in agile mode (around 67%), or more than half in any case (about one fifth and about a quarter respectively). Similar percentages are found in MPNS and ENG: at least half, or almost all, ordinary tasks are options chosen by 73.9% and 73.5%, respectively, while the percentage of respondents who claim to be able to carry out less than half of the tasks is four times more than the one found in the other domains. LS are a separate case, where respondents are practically divided into three groups based on their ability to perform less than half, more than half, or almost all the tasks. These latest data demonstrates a greater hesitation – in a context of favorable opinions – about the efficacy of agile working from this research domain.

Table 3.10. "For how much of work do you consider agile working effective" Breakdown by research domain. Total respondents: 2,921.

	Less than 50% my ordinary tasks	More than 50% my ordinary tasks	Almost all my ordinary tasks	Can't estimate
MPNS	21.4	30.9	43.0	4.7
LS	32.4	33.1	28.2	6.2
ENG	20.1	29.8	43.7	6.5
HUM	4.8	20.6	67.5	7.1
SS	5.6	24.3	67.3	2.8
All domains	22.6	30.6	41.4	5.3

6. CONCLUSIONS

We can now try to summarize our results along the research questions addressed, to understand whether the experience of smart working during the COVID-19 pandemic has positively or negatively influenced the scientific work of researchers and technologists at CNR and INFN. The expectation was to face a fast and strong capability of these professionals to adapt to the new and extraordinary working conditions, even if extreme, quickly recovering the conditions of research productivity and efficiency. Some results can be outlined.

First, the survey allows to prove that working from home was an ordinary feature of the scientific profession in public research organizations well before the advent of the pandemic COVID-19. Said differently, it is not something new that emerges for the first time due to the pandemic event, but a normal way that scholars have used in their everyday working activities. Moreover, it is true that a significant number of scholars develop core activities of their professional research life, such as drafting papers exclusively at home or without considering where they are (home or office or elsewhere). The completely new thing is, for the case under study, that the pandemic event allows to overcome some bureaucratic constraints deriving from the rules of the contractual agreement, which in principle do not admit to work at home, thus circumscribing the autonomy of researchers and technologist to decide where they can perform their activities. This special event allows scholars to develop new skill of working remotely, of changing their habits, and of learning new modes for organizing the work, with advantages affecting both the working and the familiar life.

Thus, our hypothesis was not contradicted by the findings. Indeed, the flexibility and the capability of researchers and technologists from all research domains to adapt to the new situation were impressive, and this is particularly true for those belonging to the LS, whose performance during the pandemic event of COVID-19 has improved even more than those of scholars in other fields of science, although in a comparative perspective they have shown a slightly less enthusiastic consideration towards the agile working.

The interesting element is that most of the respondents (especially those belonging to the older age cohort) pointed out the importance of having also physical interactions, denying the possibility that the scientific work could be done only using remote formats. In this respect, two main shortcomings of smart working emerged: a) the smart working during the emergency undermined the quality of the collaborations between scholars, and b) the socialization with other colleagues (professional and human relationships) were also negatively affected. Both the mentioned elements confirm that creativity in research work depends not only on abilities, intrinsic motivations, or engagement in cognitive activities (problem definition, empirical investigation, data gathering, and explanations, Shalley, 1995) but that organizational factors also

play a substantial role (Heinze et al., 2009). Among these factors, individual autonomy in research organization has a key position.

Finally, perceptions and attitudes show differences between fields, with social sciences and humanities scholars feeling more comfortable with smart working than scholars in the other fields. Gender differences, on the contrary, emerge as far as negative aspects of smart working are concerned. Scholars do not live in a vacuum: even in the case of research activities, women suffer much more than men the main disadvantages of agile working during the pandemic event COVID-19, as it was in other labor sectors.

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