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Teleworkability and the COVID-19 crisis: a new digital divide?

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Teleworkability and the COVID-19 crisis: a new digital divide?

Matteo Sostero, Santo Milasi, John Hurley, Enrique Fernandez-Macias and Martina Bisello (European Commission JRC and Eurofound)

Abstract

The paper discusses the extent of teleworking in the EU before and during the COVID-19 outbreak, develops a conceptual analysis to identify the jobs that can be done from home and those that cannot, and on this basis quantifies the fraction of employees that are in teleworkable occupations across EU countries, sectors and socio-economic profiles. Using the occupational task descriptions provided in the Italian Indagine Campionaria delle Professioni, with additional indicators from the European Working Conditions survey, we estimate that 37% of dependent employment in the EU is currently teleworkable – very close to the estimates of teleworking indicated in real-time surveys during the COVID-19 crisis. Because of differences in the employment structure, the fraction of telewokable employment ranges between 33-44% in all but five EU member states. Even starker differences in teleworkability emerge between high- and low-paid workers, between white- and blue-collar workers, as well as by gender. Results suggests that that the large expansion of telework since the COVID-19 outbreak has been strongly skewed towards high-paid white-collar employment. Yet, enforced closures have likely resulted in many new teleworkers amongst low and mid-level clerical and administrative workers who previously had limited access to this working arrangement. This is consistent with the evidence showing that, beyond differences in the industrial and occupational structures, the pre-outbreak large differences in telework prevalence across EU countries were largely driven by other factors, notably the organisation of work, regulation, and management culture. This paper also discusses some policy implications that the current experience of telework may have for the future of work.

Keywords: Teleworking; remote work; work from home; tasks; COVID-19

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Contents

Introduction

The telework revolution has been predicted intermittently for over a generation - without ever arriving. Already in 1980, Alvin Toffler's The Third Wave popularised the idea of the 'electronic cottage' which would 'shift literally millions of jobs out of the factories and offices into . . . where they came from originally: the home' (Toffler, 1980, cited in Messenger, 2019). The terms 'telework' and 'tele-commuting' were reportedly coined in 1976 by Jack Nilles in "The Telecommunications-Transportation Tradeoff," where he and co-authors argued that the congestion problem plaguing American cities could be solved by de-centralising office activities into smaller hubs, and communicating between these hubs through human messengers and mainframe computers (Newport, 2020). At the time of Nilles' writing, personal computers were not widespread; they came of age in the 1980s and their connection to the internet from the mid-1990s would lay the necessary conditions for a broader take-up of telework. For many workers, especially those in in knowledge-based sectors, these new technologies would free employees to carry on their work remotely, unshackled from their workplaces at least some of the time. The benefits would include more leisure time, enhanced work-life balance, greater work autonomy at the individual level, reduced congestion and environmental pollution at the societal level. But the reality has largely been disappointing so far. The most recent estimates from representative household surveys indicate that, four decades later, teleworking accounted for a relatively marginal share of paid labour in the EU, with fewer than one in twenty employees reporting working in this way regularly in 2018, and less than one in ten occasionally.

This all changed, abruptly and of necessity, in the first semester of 2020 as a result of public health measures designed to stem the spread of COVID-19. In the extraordinary circumstances of a viral pandemic, with many workplaces in enforced closure, a vast ad-hoc social experiment took place in which teleworking became the customary mode of working for many employees with hitherto limited or no experience of working in this way.

This is notably the case for those carrying out office-based work, especially in service sectors, who are largely reliant on intensive networked computer use. In the main, these are sectors where workers enjoy many labour market advantages – less physically arduous working conditions, higher pay, greater job security (Adams-Prassl et al, 2020). These advantages have been sharpened by COVID-19 as such work – and the businesses and employment relationships that depend on such work – has proved more resilient than much customer-facing service work, in sectors like air travel, tourism and hospitality, and restaurants.

In this paper, we quantify the extent of teleworking before and during the COVID-19 outbreak, develop a broader conceptual analysis of teleworkability and sketch how the present experience may precipitate lasting changes in work organisation, who the beneficiaries of such changes may be and what issues such changes may raise for workers, employers and policy-makers. The paper explores these issues focusing mostly on the pre- and post-outbreak trends in telework among dependent employees. That is because dependent employees, more than the self-employed, are those who have experienced the largest increase in teleworking because of the COVID-19 outbreak, while also being more likely to witness long-lasting changes to their work organisation looking forward. Indeed, the need to work from home induced by the outbreak has removed, at least temporarily, many of the barriers that may have limited the adoption of telework over the past decade – e.g., regulation, norms of office work, and the unwillingness of employers and managers to extend unsupervised autonomy, driven by a lack of trust. To what extent these barriers may decline further in the future remains uncertain.

The paper is structured as follows. In a first section, we present data on teleworking incidence pre-COVID-19 from representative European surveys as well as first indications of its expanded incidence post-COVID-19 based on real-time survey data. First estimates show that the share of those teleworking regularly has increased anywhere from 3-5% to a third or more of employees at

EU level, with significant variations across member states, and between North and South, and between East and West.

This huge expansion in telework calls for a reflection on what exactly it is that makes some occupations amenable to it, while others are not, beyond the specific contingencies of pandemic-induced social reorganisation. In a second section, we develop and operationalise our hypothesis. Based on a conceptual framework of work tasks and on the state of current technology, we argue that the ultimate determinant of occupational teleworkability is the lack of physical handling tasks. Occupations rich in such tasks – those for example of nurses, of production line workers in manufacturing, of farmers – simply cannot be performed remotely with the available technologies. In principle, all other jobs may be performed remotely or from home, with varying degrees of difficulty. There are additional factors that either constrain or qualify the ability to telework – such as the extent of social interaction required in a job – while other factors facilitate it – such as the infrastructure for ICT connectivity in computer-facing knowledge-based work. These are discussed in the text, but it is our contention that the main impediment to teleworkability are physical handling tasks that mean a job can only reasonably be performed in specific locations. This follows in part the insight of the first analysis of teleworkability published soon after the onset of the crisis (Dingel and Neiman, 2020) and tries to provide a firmer conceptual underpinning for that insight based on an existing job tasks framework (Fernandez-Macias and Bisello, 2020).

The approach taken is similar to that of earlier research designed to measure the extent of either "offshorability" (Blinder, 2009) or of "automatability" (Frey and Osborne, 2017) of jobs in advanced economies, where the task characteristics of jobs are used to proxy their exposure to potentially disruptive forms of change. Both widely-cited works were criticised regarding the high estimates of vulnerable employment and imprecise time-scale of the effects. The rejoinder of the authors was in both cases that their estimates were based on a technical potential – of offshorability, automatability – rather than predictive forecasts of actual offshoring or actual automation of jobs. This was prudent, as the incidence of actual offshoring or mass automation and consequent employment displacement in advanced economies largely has failed to materialise. By contrast, the change considered in this paper – in this case, mass telework – was not expected to occur so suddenly (Schwind and Llave, 2019). During the COVID-19 lockdown, all or nearly all jobs that were teleworkable in late April 2020 were being performed from worker's homes.

In a third section, we present a classification of occupations in terms of technical teleworkability. This is based on a job-tasks framework and assigns teleworkability values to over 130 occupations (ISCO 3 digit) based on the conceptual approach previously described. The main source for this classification is the detailed occupational task descriptions from the Italian Indagine Campionaria delle Professioni with additional indicators from the European Working Conditions survey. Based on this classification, we then assess the shares of teleworkable employment based on the classification developed. We estimate that around 36% of dependent employment in the EU is currently teleworkable, very close to the estimates of teleworking indicated in real-time surveys during the COVID-19 crisis. There are variations in incidence by member state based on differences in employment structures, even starker differences between well-paid workers and low-paid workers, between white-collar and blue-collar workers but also – perhaps more surprisingly – by gender.

A fourth section discusses how teleworking might develop following the current expansion. It highlights some policy implications in terms of work organisation, regional and international inequalities, an occupational health and safety. A final section summarises and concludes.

Working from home in the EU before the COVID-19 pandemic: what we know

Before the COVID-19 outbreak, there was clearly a wide gap between the number of people who could work from home, and the number who actually did so. In 2019, around one in twenty workers worked from home regularly – far below estimates of one third or more of workers who did so in the first semester of 2020. In this section, we outline the evidence for the EU on the pre-outbreak prevalence of work from home/teleworking among dependent employees, using data from the European Labour Force survey, the European Working Conditions survey, and EU surveys on ICT usage.

In particular, what follows tries to answer to the following questions:

- How common was telework in the EU before the COVID-19 pandemic? And for whom?
- Where in the EU was telework more widespread before the COVID-19 crisis? And why?

Which were the prevalent working conditions of teleworkers before the COVID-19 outbreak?

Box 1: "Remote working ", "teleworking" or "working from home"? – a question of definition

The terms "remote working", "teleworking", "working from home" each relate to the spatial distribution of work. These concepts are interrelated and, inevitably, have some degree of overlap. Among these, "remote work" can be considered the broadest concept. It describes the situations where the work is fully or partly carried out at an alternative worksite than the default place of work (defined as the employer's/client's premises or public space where work is usually carried out) (ILO, 2020). In principle, remote working could be done anywhere and not necessarily in the worker's home (e.g. in a third-party hub or shared office, while travelling or on the road). Both dependent workers (such as employees and dependent contractors) and independent workers can be considered as remote workers if they perform part or all of their work away from their default worksite. Eurofound's ICT-based mobile work definition (Mandl et al., 2015) is similarly boundary-free.

Telework can be considered as a subcategory of the broader concept of remote work. Although there is no internationally recognized definition, what is often considered specific to telework is that the work carried out remotely entails the use of personal electronic devices, such as computers, tablets or mobile phones. Moreover, the concept of telework is often restricted to employees only (Mandl et al., 2015; Messenger et al., 2017). For instance, the 2002 EU social partners' framework agreement on telework defines telework as "a form of organising and / or performing work, using information technology, in the context of an employment contract / relationship, where work which could also be performed at the employer's premises is carried out away from those premises, on a regular basis" (see Vargas Llave et al., 2020).

The third concept, "working from home" refers to work that takes place fully or partly within the worker's own home. Unlike the concepts of "remote work" and "telework", the concept of "working from home" is independent of the default place of work (see ILO, 2020). Both independent and dependent workers can be "working from home" – e.g. employees who perform home-based remote work, as well as self-employed engaged in artisanal production or industrial piece-rate production carried out from home (ILO, 2016:2 fn).

In this paper, we focus primarily on dependent employees and therefore on **the remote provision of labour that would otherwise be carried out within the employer's premises**. In particular, our main focus of interest is the type of remote work that has become common since the advent of the COVID-19 crisis, with employees working remotely from home, using ICT, as opposed to working from an employer's workplace. Many of the relevant questions in the survey data sources used in this paper only capture the extent of employees who are "working from home" – a simpler concept than telework.

However, as shown in this section, most of the employees who regularly or sometimes "work from home" typically make intensive use of computers while at work and can, therefore, be safely regarded as home-based teleworkers. For this reason, the terms "working from home" and "teleworking" are sometimes used interchangeably throughout the paper even though, as indicated above, each term denotes something quite specific.

How common was telework in the EU before the COVID-19 pandemic? And for whom?

Telework – henceforth meant as the practice among dependent employees of usually or sometimes working from home – was slowly becoming more prevalent in the 10 years leading to the COVID-19 outbreak, both among dependent employees and the self-employed, although mostly on an occasional rather than on a regular basis (see Figure 1, page 9).

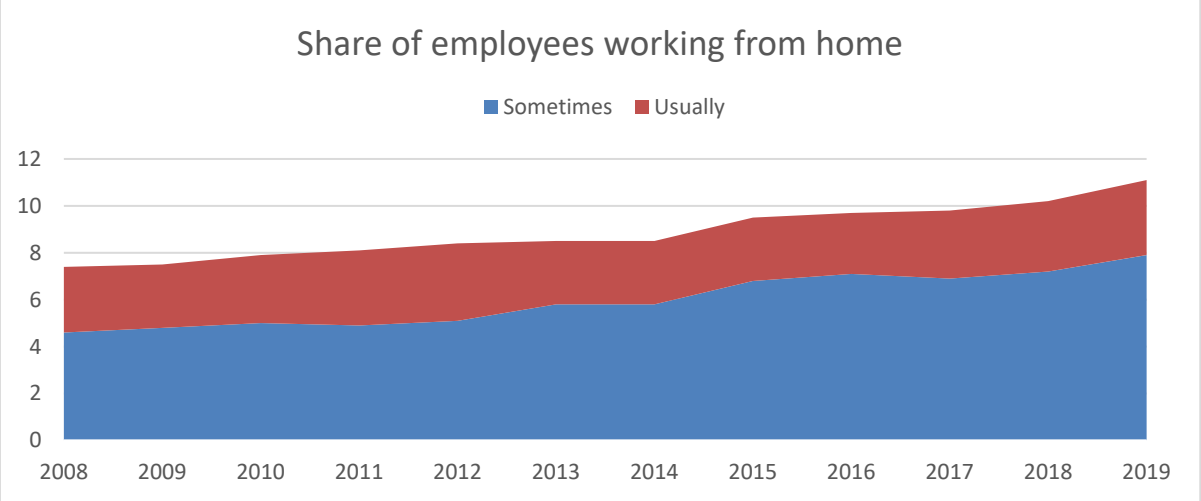
In 2019, around 11% of dependent employees were working from home at least some of the time, up from less than 8% in 2008[1]. Yet, just 3.2% of employees in the EU-27 usually worked from home – a share that remained rather stable since 2008. Working from home was marginally more widespread among older employees than younger ones, while the incidence by gender was very similar. Although it is outside the scope of this paper, it is important to keep in mind that a significant share of self-employed were also working from before the COVID-19 crisis, and many of them on a regular basis (see Box 2, page 9).

There are differences in the labour market profile of regular vis-à-vis occasional teleworkers. For instance, according to figures from EU Labour Force Survey (LFS), working from home occasionally is twice as likely amongst permanent – as opposed to temporary – employees, and more likely among full-timers – as opposed to part-timers. By contrast, employees who usually work from home are just as likely to be temporary as permanent and more, not less, likely to be part-timers than full-timers. They are also nearly twice as likely to have other jobs.

These observations confirm the heterogeneity of teleworkers. While higher-skilled, higher-paid jobs are over-represented – especially in the 'occasional' category – there is also a small but significant pocket of part-time, low-paid and multiple job holders working from home, notably among regular homeworkers.

[1] These figures from the EU-LFS are closely matched by those from the most recent European Working Conditions survey (2015) where 12% of EU employees reported working from home at least a few times per month, with 4% doing so daily.

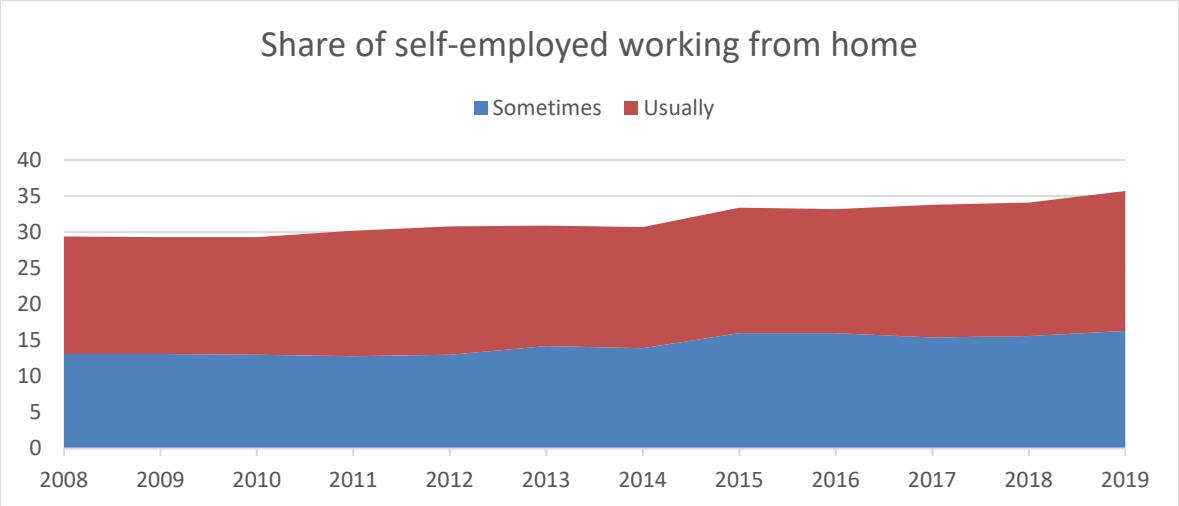
Figure 1: Evolution of telework among employees in the EU-27 by frequency, 2008-19, %



Box 2: Self-employment and work from (at) home: an overview across sectors.

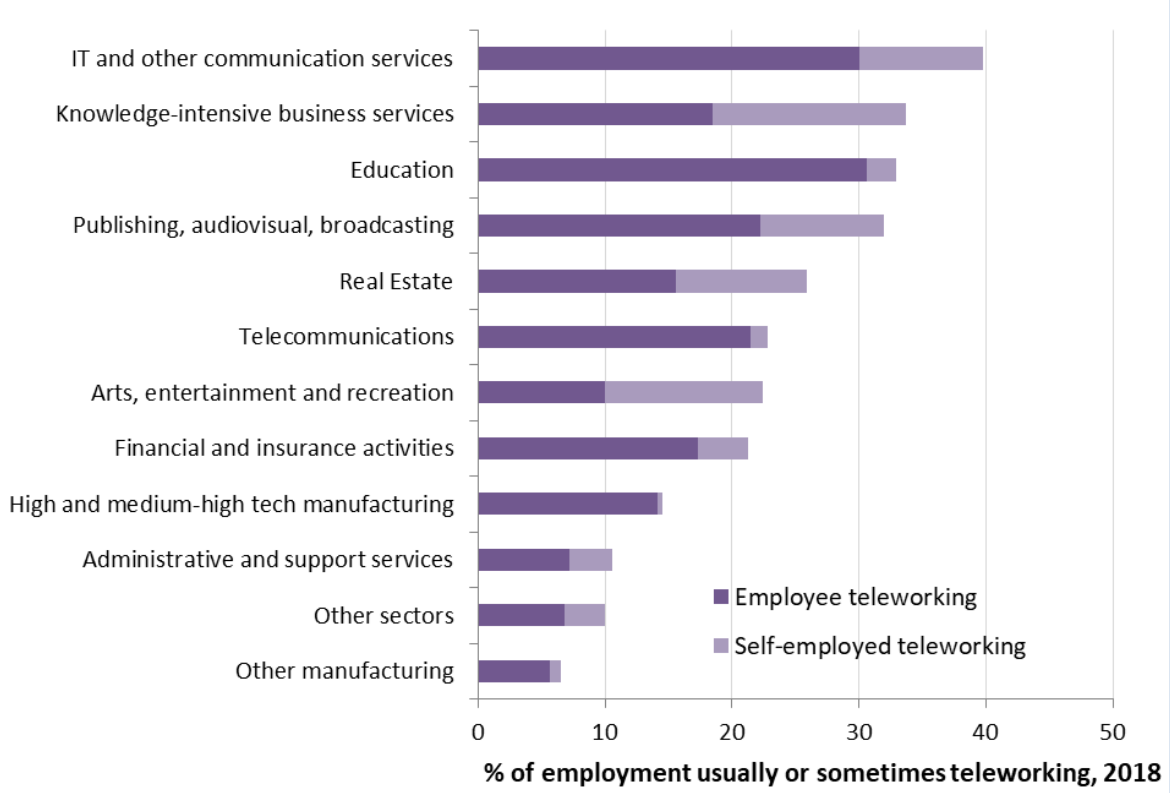
Over a third (35%) of the self-employed reported working from home sometimes or usually in the 2019 LFS, compared to 29% in 2008 (see Figure 2 below). More than 19.4% of the self-employed was usually working from home, while another 16.3% was doing so on only sometimes. A higher rate of telework among self-employed is to be expected, insofar as for many own-account workers – who account for over 80% of total self-employment – the home is by default also the place of work and production. Hence, figures for telework among the self-employed include not only those "working from home" using ICT, such as designers or software developer, but also those "working at home" without ICT, such as home-based small artisans who sell their products on a piece-rate remuneration system and work where they reside. However, note that the self-employed in the former category represent a sizeable fraction of all teleworkers in many knowledge- and ICT-intensive sectors. For instance, in 2018, own-account self-employed represented almost 50 per cent of all teleworkers in knowledge-intensive business services, and around one fourth of teleworkers in ICT activities.

Figure 2: Evolution of telework among self-employed in the EU-27 by frequency, 2008-19, %



***Source**: Eurostat, LFS. (variable code: lfsa_ehomp)*

Figure 3: Telework by sector and professional status, EU-27, 2018

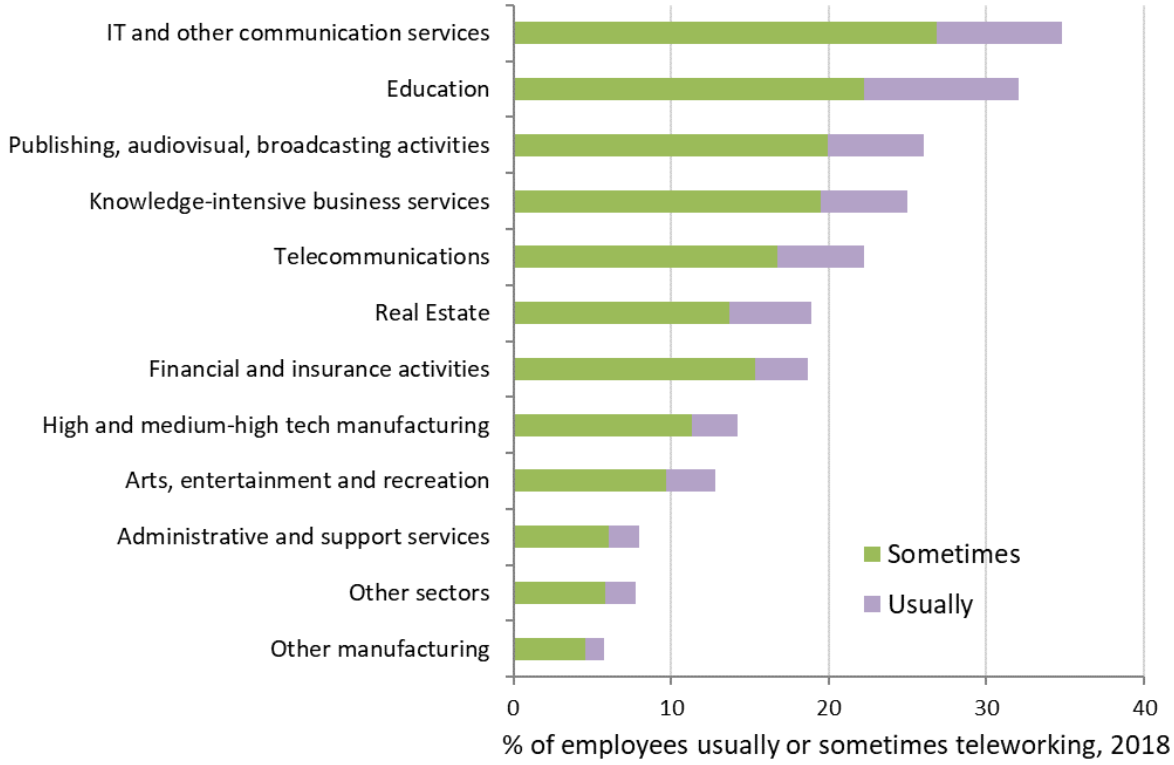


Note: *See note to Figure 4for the detailed definition of the sectoral aggregates.*
Source*: author's calculations from ad-hoc extractions of EU-LFS provided by Eurostat.*

Close to 35% of employees in IT and other communication services in the EU-27 worked from home regularly or at least with some frequency in 2018. This share was comparatively high in publishing activities (25%, see Figure 3 above) and in a range of knowledge-intensive business services (26%) as well as in education (32%).

The high prevalence of homeworking in education – also observed in European Working Conditions Survey (EWCS) data – invites questions about exactly what type of work tasks are being carried out at home. It seems probable that teachers (correctly) consider preparing classes or grading papers from home as work from home, and that this explains the high sectoral incidence of occasional telework (see Figure 4, page 11). Traditionally, teaching is largely place-dependent (schools, colleges) and normally involves interacting with students in person, so it is unlikely to have been performed from home in 2015, when the EWCS was carried out. Of course, the incidence of teleworking is equally likely to have risen sharply in education following post-COVID-19 school closures. This does however raise two important issues about working from home more generally. Firstly, many occupations – even ostensibly place-dependent ones – may comprise both teleworkable and non-teleworkable elements that are easily separable and are therefore amenable to occasional teleworking. Secondly, on the assumption that many other high-skilled white-collar employees do some work-related activity at home, the extent to which this is recorded as telework (rather than as 'working in their free time') appears to vary broadly by occupation. This may relate partly to whether such off-premises work is formally or contractually recognised as part of their core responsibilities, as is likely to be the case for teaching professionals.

Figure 4: Prevalence of telework by sector, EU-27, 2018



Note: *The group "Knowledge-intensive business services" includes the following sectors: Legal and Accounting Activities - Activities of Head Offices; Management Consultancy Activities - Architectural and Engineering Activities; Technical Testing and Analysis - Scientific Research and Development - Advertising and Market Research - Other Professional, Scientific and Technical Activities. The group IC and other communication services include: Computer Programming, Consultancy and Related Activities - Information Service Activities.*

Source*: author's calculations from ad-hoc extractions of EU-Labour Force Survey data provided by Eurostat.*

The sectors of telecommunications, finance and insurance also have relatively high shares of teleworkers – around 20%. Conversely, the share of teleworkers was rather low in administrative and support services as well as in manufacturing. In addition to the nature of the service provided, higher rates of telework across knowledge- and ICT-intensive business services are largely explained by the fact that professionals, amongst whom telework is typically more widespread, account for a larger share of employment in these sectors than in others.

As suggested above, teleworking is traditionally more common in high-skilled, white-collar occupations, such as managers and professionals. Whilst the outbreak of the pandemic has forced growing numbers of workers to work from home, pre-outbreak telework was mostly the preserve of those doing most of their work on computers, enjoying high degrees of autonomy, and employed in knowledge-intensive activities. Within this group, the highest prevalence of telework before the COVID-19 outbreak was found among teachers (43%, see Figure 5) and ICT professionals (41%), followed by managers and professionals working in legal, business, administration, and science.

Beyond the nature of their work, high rates of working from home among some professionals may also reflect the extent to which they perform informal overtime work – such as correcting homework, checking emails and reading specialised literature – at home.

Figure 5: Prevalence of telework by occupation, 2018, EU-27 (% of total employment)

Note: *The graph refers to total employment. Occupation-specific data on the frequency of working from home disaggregated by professional status are not available.*

Source: *author's calculations from ad-hoc extractions of EU-LFS data provided by Eurostat.*

As shown in the following sections, the confinement measures introduced after the onset of the COVID-19 crisis have likely induced a spread of telework also among mid- and low-skilled white-collar occupations. For instance, in 2018, less than 20% of ICT technicians and 10% of general keyboard clerks and other clerical support workers had experienced some form of telework.

These are occupations with a high intensity of computer use, which in principle should facilitate working from home. Yet, before the COVID-19 crisis, they rarely used this type of work arrangement. In general, mid- and low-level occupational groups had a much lower incidence of telework than managers and professionals. Junior professionals show much lower frequencies of telework for example than their counterparts in more senior positions.[2]

Other occupations, by their very nature, are difficult or impossible to perform remotely. This is the case of most of healthcare workers, sales workers, waiters / servers, or personal service workers such as hair stylists or housekeepers, who are among the least likely to work from home among major occupational groups.

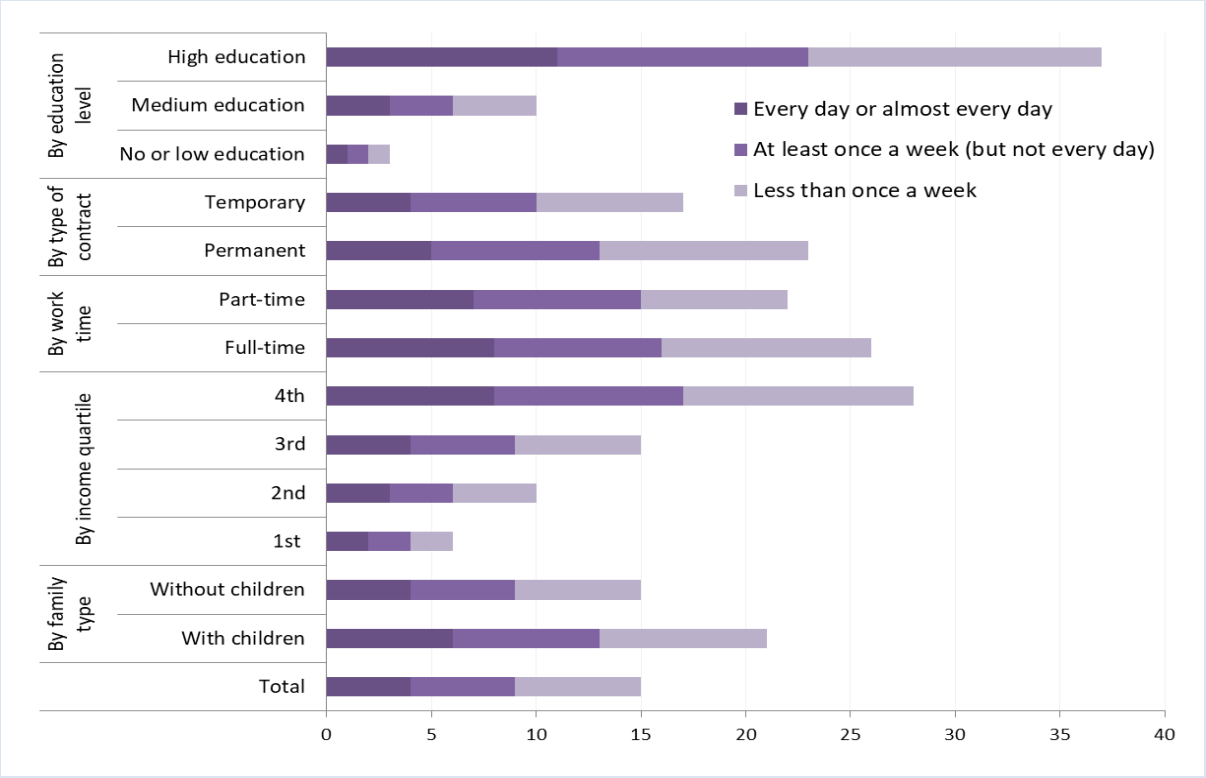
Consistent with the higher prevalence of telework among managers and professionals, it is not surprising that access to telework was greater among the higher-qualified and well-paid employees (see Box 3, next page).

[2] According to EWCS data, employees in supervisory positions were more than twice as likely to telework as non-supervisory employees, with nearly all of the difference accounted for by occasional teleworking.

Box 3: Disparities in access to telework reflect other dimensions of labour market inequality.

Data from *the EU survey on ICT usage among workers* allow to complement our understanding of the socio-economic profile of the typical teleworker before the onset of the COVID-19 crisis.[3] These data show that close to 40% of workers who completed tertiary education worked from home with some frequency, against an average of 10% of those with secondary education and around 3% for those with low or no education (see Figure 6 below). Similarly, around 25% of workers in the top quartile of the EU-27 income distribution have access to telework – a share that declines to less than 10% among those in the bottom half. Telework was also slightly more common among those in standard employment contracts, with higher shares for those with permanent and full-time work contracts. Interestingly, workers with children teleworked slightly more than people without them. This may suggest that employers and employees have, at least in part, been using telework to balance work and family life. Finally, echoing findings stemming from the EU LFS data, no significant gender differences in the prevalence of telework are detected in the *EU survey on ICT usage among workers*

Figure 6: The socio-economic profile of teleworkers



Note: *Figures refer to the share of employee working from home by frequency of working from home.*
Source: *Eurostat, ICT usage among workers survey (variable code: isoc_iw_hem)*

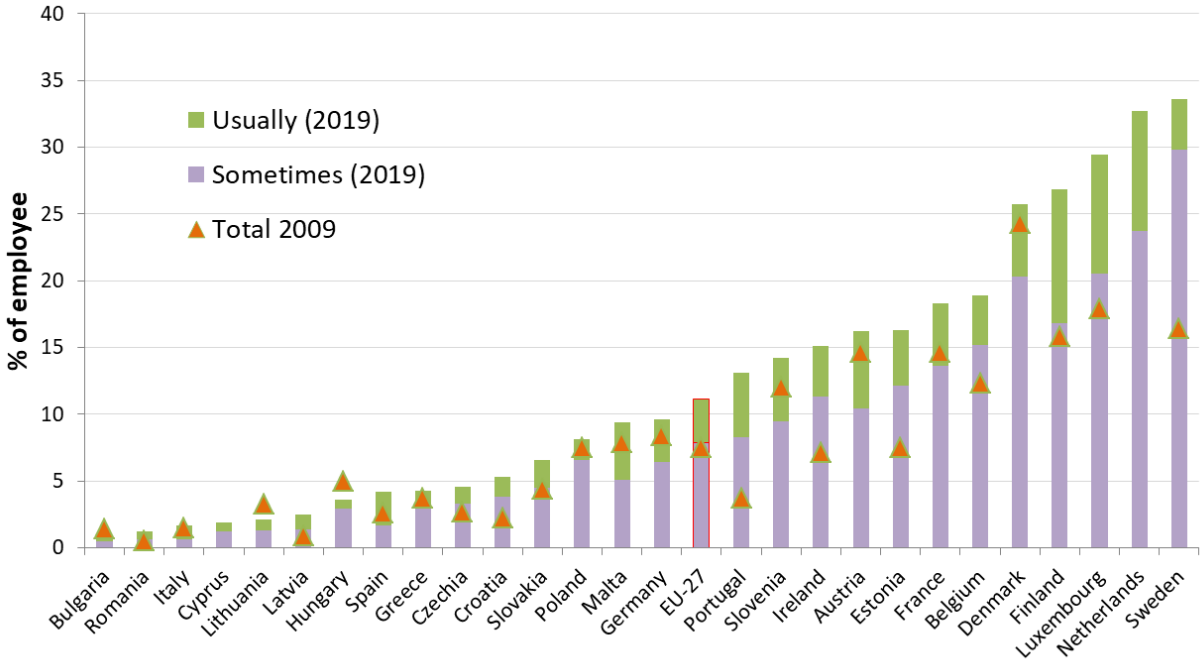
[3] Figures on the overall prevalence of working from home from the EU survey on *ICT usage among workers* are slightly larger than those retrieved from the EU LFS, and the most recent European Working Conditions survey (2015). In fact, according to this survey, 5% of EU-27 employees reported working from home every day or almost every day in 2018, 7% reported doing so at least once a week (but not every day), while another 10% reported working from less than once a week.

Where was telework more widespread before the COVID-19 crisis? And why?

The ability to effectively adapt to large-scale teleworking is likely to differ significantly across EU countries**.** Pre-outbreak, there were large, and growing, differences in the prevalence of telework across its Member States. As of 2019, the share of employees working from home regularly or at least sometimes was above 25% in most Northern European countries, including Sweden, Finland, and the Netherlands, whereas it was below 10% in 15 of the 27 EU Member States (see Figure 7, below).

Between these two extremes, there were countries such as Belgium, France and Portugal where the share of telework ranged between from 13 and 19%. Countries in Northern Europe are also those with the largest growth in the prevalence of telework since 2009, albeit sizable increases also took place in a number of other Member States including Portugal, Estonia, and Ireland.

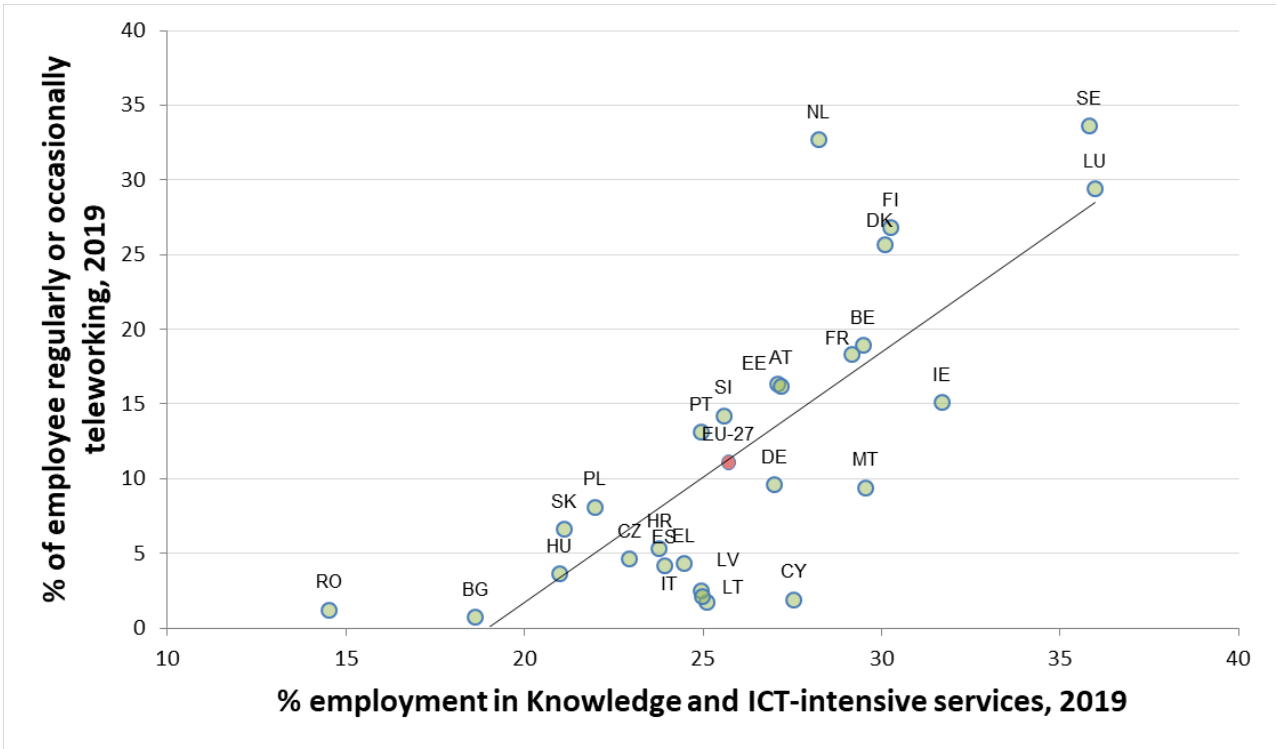
Figure 7: Prevalence of telework across EU Member States in 2009 and 2019, (% of employees)



Note: *Data on the frequency of telework in 2009 are not available for the Netherlands and Cyprus.*
Source: *Eurostat, LFS. (variable code: lfsa_ehomp).*

Differences in industrial structures is one of the main factors explaining varying prevalence of telework across EU countries. Countries such as Sweden, Finland, and the Netherlands, where workers in knowledge- and ICT-intensive service sectors account for a larger share of total employment are not surprisingly those where telework is more widespread (see Figure 8, next page).

Figure 8: Industrial structure of employment and telework



Note: *Knowledge and ICT intensive sector include: Publishing activities, Motion picture, video and television programme production, sound recording and music publishing activities Programming and broadcasting activities, Telecommunications, Computer programming, consultancy and related activities; Information service activities, Legal and accounting activities, Activities of head offices; management consultancy activities, Architectural and engineering activities; technical testing and analysis, Scientific research and development, Advertising and market research, Other professional, scientific and technical activities, Education, Human health activities, Creative, arts and entertainment activities.*

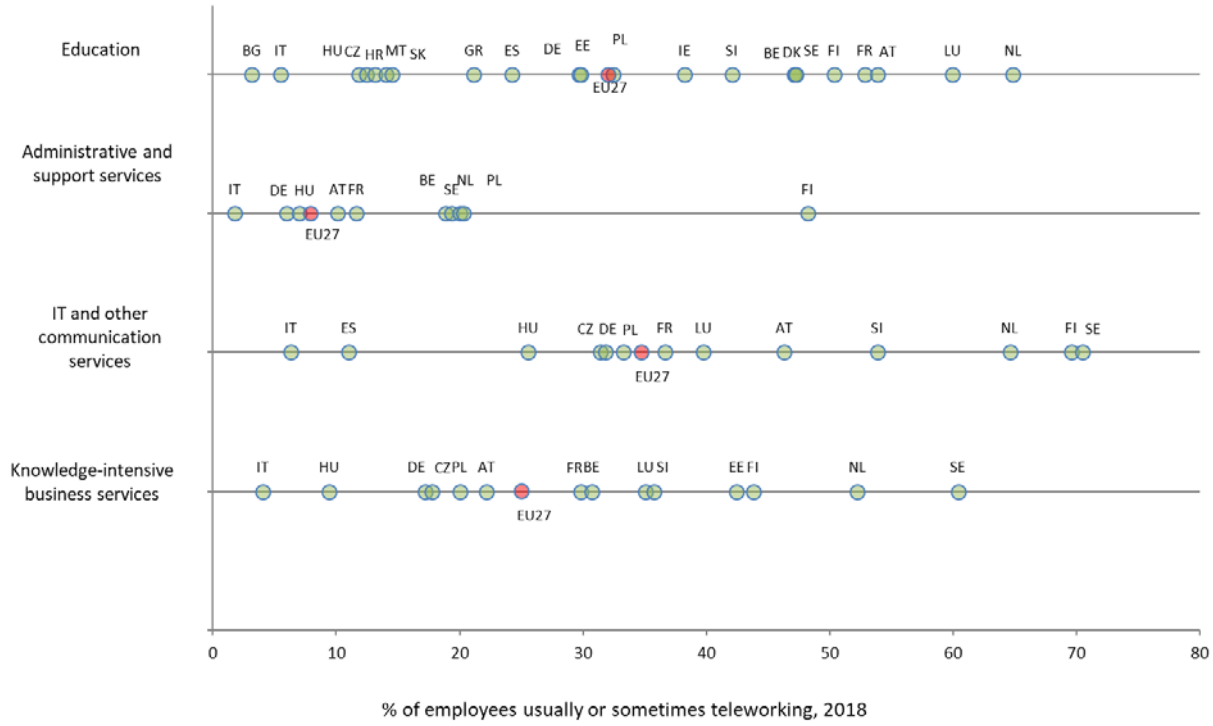
Source: *Authors 'calculations based on Eurostat, LFS.*

Yet, even across knowledge- and ICT-intensive services, there are significant difference across countries. Figure 9 shows that, before the outbreak of the pandemic, differences in the share of teleworkers across EU countries were sizable even within the same sector. For instance, while more than 50% of workers in knowledge-intensive business services were, usually or sometimes, teleworking in Sweden and the Netherlands, this share was below 25% – the EU-27 average – in Austria (22%), Germany (17%), and Italy (4%). Similar degrees of cross-country heterogeneity in the prevalence of telework can be observed in education, IT and communication, and to a lesser extent in administrative and support services.

Overall, this evidence suggests that, beyond differences in the industrial structure, the heterogeneous prevalence of telework across EU countries may significantly depend on other within-sector differences, including differences in the occupational mixes, the distribution of employment by firm size, the rate of self-employment, workers' and firms' affinities with digital technologies, as well as organisation and management cultures.

Different regulatory frameworks (legislation, collective agreements) may also support or hinder deployment (Vargas Llave and Weber, 2020). Looking forward, all these factors are likely to shape the pace, scale, and effectiveness of a wider adoption of teleworking across sectors, firms, and in turn countries.

Figure 9: Prevalence of telework by country in selected sectors, 2018



Note: *see note to Figure 4 for a detailed definition of the sectoral groups.*

Source: *Authors' calculations from ad-hoc extractions of EU-LFS data provided by Eurostat.*

Box 4: Differences across countries in the prevalence of telework: Decomposing between and within variation of industries and occupations.

Before the outbreak, there were large differences in the prevalence of telework across countries, as shown in Figure 6. These cross-country differences, that can be measured using the EU-LFS as our source, are mostly explained by: i) Differences in the industrial and occupational structures of employment, ii) Differences in characteristics within sectors and occupations, such as the occupational composition of the workforce in a given sector, and the way the work of each occupation is organised. In order to provide a first assessment of the relative importance of these factors in explaining the differences in the prevalence of telework across countries, we compare the share of telework across EU countries to that of Sweden, the reference country, and the related difference is decomposed into differences in the industrial/occupational structure of employment (between component) and differences within industries/occupations (within component) (for a similar decomposition approach see Nedelkoska and Quintini, 2018). We decompose the change in the prevalence of telework according to the following formula:

$$\Delta T_c = \sum_i \left(\Delta Empl_{i,c\neq SE} * T_{i,SE}\right) + \sum_i \left(Empl_{i,SE} * \Delta T_{i,c\neq SE}\right)$$

The total difference in the prevalence of telework (ΔTc) between any country (c) different from Sweden ($c \neq SE$) and Sweden can be decomposed into a *between* sector/occupation component $\sum_i(\Delta Empl_{i,c\neq SE} * T_{i,SE})$ and a *within* sector/occupation component $\sum_i\left(Empl_{i,SE} * \Delta T_{i,c\neq SE}\right)$.

The term $Empl_i$ is the employment share in a specific industry and occupation-specific, and T_i is the prevalence of telework in a specific industry and occupation; i indicates the sector/occupation. Figure 10 and Figure 11 below show the results of this decomposition for industries and occupations respectively.

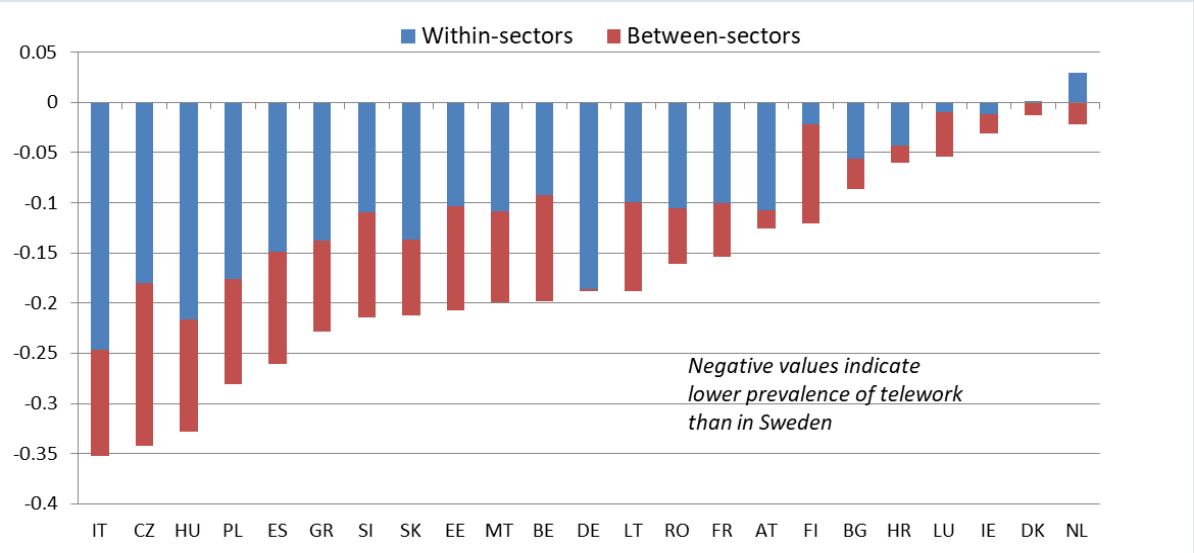
Differences in the industrial and occupational structures do matter in explaining the overall differences in the spread of telework across countries – as indicated by the contribution of the *between* component for sectors and occupations shown in Figures 10 and 11 below, respectively.

However, for the majority of the EU countries, the *within* component explains most of the deviation in telework rates from Sweden, both along the sectoral and the occupational dimension. For instance, the within-sectors variance accounts for 60% of more of the total difference in countries such as Greece, Poland, Hungary and Italy, explaining even larger fractions in Germany or Austria. A broadly similar picture emerges when the prevalence of telework is decomposed along the occupational dimension.

Taken together, these findings suggest that the differences in the uptake of telework between Sweden and most of the other EU countries primarily depend on different rates of telework in the same sector and occupation, and only secondarily on the fact that Sweden has a larger share of employment in telework-compatible sectors and occupations. This largely reflects the fact that, with respect to Sweden, many EU countries show smaller shares of telework-compatible occupations within any given sector, while also organising and managing the work of each occupation in a way that is less conducive to telework.

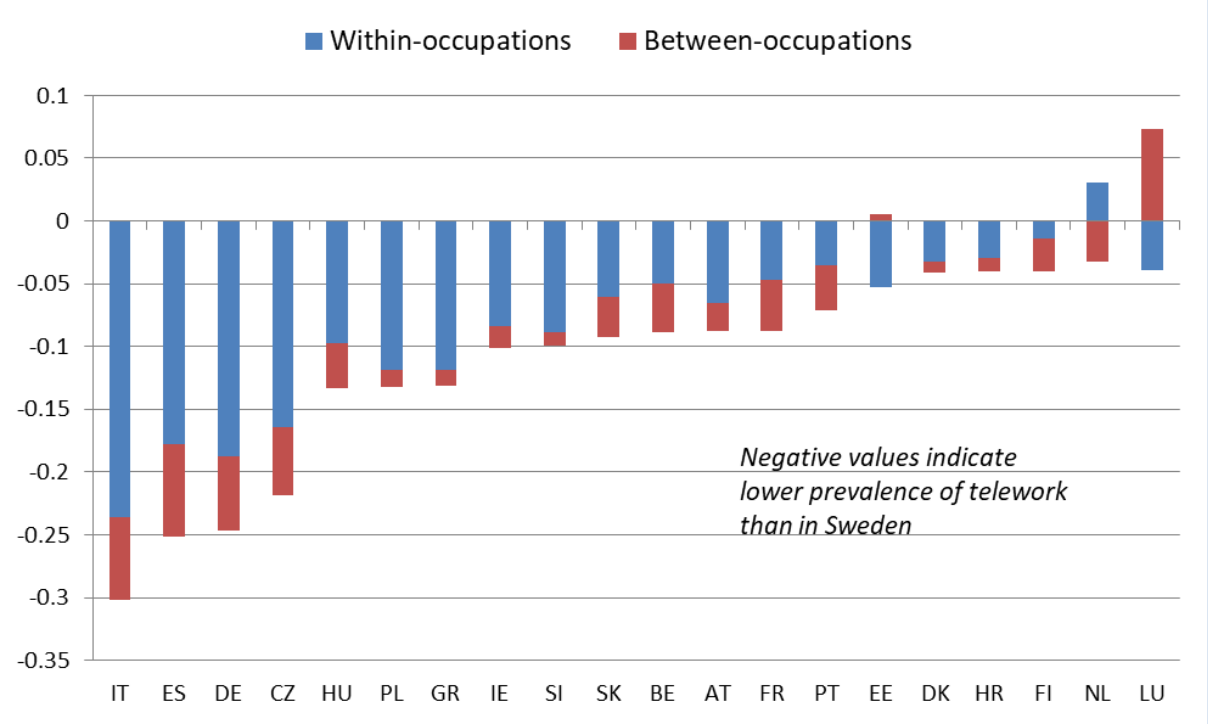
Conversely, when Sweden is compared to other Northern European countries, such as Finland and Denmark, the contribution of within component remains rather modest. That is because Sweden and the other Northern European countries tend to have quite similar occupational structures within any given sector and to adopt similar forms of work organization. As a result, differences in rates of telework among these countries are largely driven by differences in the sectoral and occupational structures.

Figure 10: Sectoral decomposition of the differences across countries in the prevalence of telework



Source: *authors' calculations from ad-hoc extractions of EU-LFS data provided by Eurostat*

Figure 11: Occupational decomposition of the differences across countries in the prevalence of telework

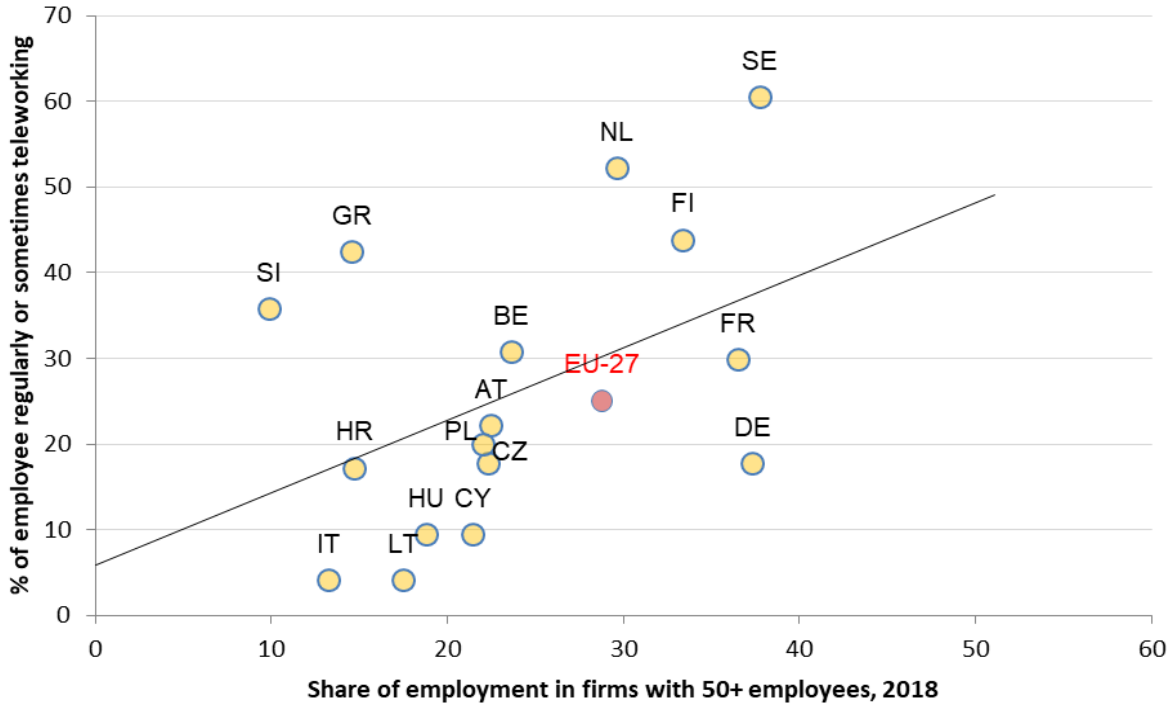


Source: *authors' calculations from ad-hoc extractions of EU-LFS data provided by Eurostat*

Larger companies are more likely to adopt flexible work arrangements (including teleworking) than smaller ones. For instance, the share of teleworkers in knowledge-intensive business services is higher in countries such as the Netherlands, Sweden, and Finland where between 30 and 40% of the workforce in the sector is employed in firms with 50 employees or more (see Figure 12, next page). Conversely, this share is considerably lower in countries such as Italy and Croatia, where firms with 50+ employees account for less than 15% of employment in knowledge-intensive business services.

There are of course some notable exceptions to this pattern. For example, the share of teleworkers in these sectors is relatively high in Greece and Slovenia despite the very low concentration of employment in medium- and large-sized enterprises, whereas the opposite is true in Germany, and to a lesser extent in France.

Figure 12: Telework and employment by firm size, knowledge-intensive business services, 2018



Note: *see note to Figure 4 for the definition of knowledge-intensive business services*

Source: Authors' calculations from Eurostat, LFS.

Telework and working conditions before COVID-19 pandemic

The previous subsection showed where home-based telework was most common in the EU before the COVID-19 crisis, across countries, sectors, and occupations. Using data from the European Working Conditions Survey (EWCS), this section sheds light on the pre-outbreak working conditions of teleworkers – following our definition, those who reported working from home at least some of the time – and how these differ from those of employees who never worked from home.

The main advantage of the EWCS over the EU-Labour Force Survey (LFS) is its broader coverage of dimensions on quality of work, such as working time, worker autonomy, job satisfaction and health outcomes. It also includes useful details on the methods and tools of work – including computer use – which may be correlated with the ability to work remotely. This information helps us describe the conditions of those working from home, beyond the demographic and job-related variables already indicated.

Before the COVID-19 crisis, those who regularly worked from home full-time put in longer hours – 40.8 hours per week on average, compared to 39.8 hours per week for those who never worked from home. Even greater differences have been identified in other studies of European teleworkers (Schwind and Vargas, 2019), who found that the share of teleworking and mobile working employees working very long hours (>48 hrs per week) is much greater than that of non-teleworking counterparts, especially among male employees.

Teleworkers also spent more time commuting to work (46-50 minutes per day compared to 40 minutes for those who never work from home). Perhaps those with longer commutes were also more likely to apply for homeworking. There is no significant difference between those who worked from home at least occasionally and those who did not, in terms of subjective indicators like job satisfaction, or their satisfaction with work-life balance (measured by the question 'how do your

working hours fit in with your family or social commitments outside work?'). There is also no difference in terms of proxy indicators for work intensity, such as working to tight deadlines or at high speed.

Those who worked from home at least occasionally are more likely to report that their work affects their health positively, though they are also somewhat more likely to report higher levels of stress (14% of them report feeling stress at work 'all of the time', compared with 9% of those who never work from home). One strong difference is in the lack of boundary between work and home life – 37% of regular homeworkers, 18% of occasional homeworkers but only 4% of those who homework 'less often' or 'never' report having to work in their free time either daily or several times a week.

In relation to work content, teleworkers were much more likely to report that their work involves high levels of autonomy and is cognitively rich (involves learning new things or complex tasks), which is unsurprising given their occupational and skills profile as discussed in the previous section.

The survey also shows that computer use is correlated with the telework incidence, though the correlation is lower than might be expected. Those who worked from home (notably on an occasional basis) are highly likely to report intensive computer use in their work (working with computers 'all of the time' or 'nearly all of the time'). Yet, intensive computer use is also reported by employees who never worked from home. This suggests that, among all the factors driving telework, computer use is an enabling technology, but ultimately matters less than the task content of one's occupation, or the position in the organisation.

Perhaps a more surprising finding is the extent of regular social interaction, including activities like dealing with non-colleagues such as clients, pupils, and patients, among those who work from home at least sometimes. One would expect that social interaction is an impediment to working from home, under the assumption that the social tasks involved are in many cases more difficult (or even impossible) to be carried out from home. But this appears not to be the case in practice. It may be that some of those social tasks are apt to be performed remotely using existing technology – e.g. via phone, email, or video-conferencing – without necessarily losing quality. An alternative explanation could be that teleworkers are able to compartmentalise tasks that require face-to-face interaction with non-colleagues in those periods when they are not teleworking. This ability to compartmentalise one's work into teleworkable and non-teleworkable tasks is itself evidence of a high degree of work autonomy. As we have seen, a large share of occasional telework is carried out by managers and professionals, occupations both rich in social interaction and with high levels of work autonomy.

The European Working Conditions Survey paints a picture consistent with the EU Labour Force Survey of the cross-country variation in the extent of working from home arrangements, with a high incidence in the Benelux and Nordic member states and a relatively lower one in Germany, Italy and Spain. It also presents a similar profile of the archetypal teleworker – more experienced, autonomous, highly educated, well-paid employees, working in higher level occupations, often as knowledge workers in services. Such a profile applies in particular to those who occasionally work for home, where this condition appears to be partly a privilege associated to high professional status, in part a compensation for longer hours working and blurred boundaries between professional and personal life.

Work from home during the COVID-19 pandemic: first evidence from real-time surveys

In response to the COVID-19 pandemic, several surveys have tried to estimate how many people were working from home, following the confinement measures that restricted mobility and led to the shuttering of many workplaces. In this section, we summarise results from some ad-hoc, real-time surveys. These sources can fill the gap resulting from an obvious weakness of official household or periodical surveys in covering unanticipated and fast-moving events such as a pandemic and its effects – the time lag between data collection and publication[4]. EU-LFS quarterly data is only published 3-4 months after the end of the quarter in question. It will be mid-summer 2020 at the earliest before the beginnings of the employment impacts of the crisis are evident in the EU-LFS. Each of the surveys cited below [5] has been mobilised quickly, in real time and online, either using an existing panel of respondents and with a claim to representativeness in the countries covered (University of Mannheim, University of Oxford, US Federal Reserve Board, UK ONS), or using an open online survey (Eurofound, Whitaker Institute/NUIG). While post-stratification weights were used in the latter surveys to adjust samples to known population shares for standard demographic variables, biases in the raw samples (disproportionately large female and tertiary-educated shares of respondents, for example) suggest that some caution should be taken in interpreting the results.

The most extensive real-time survey source in Europe is **Eurofound**'s COVID-19 survey, an online survey initiated in April 2020 which received nearly 62,000 completed responses in the EU member states in a first round (fieldwork: April 7th-April 30th)[6]. Of interest to this paper, in a small battery of work-related questions it asked on whether respondents had taken up teleworking / working from home following COVID-19 confinement measures and whether they had previous experience doing so.

In the Eurofound study, over a third (39%) of employees currently working in the EU started to work from home following the pandemic, compared to 20% who indicated working from home at least 'several times a month' pre-COVID. Those who were working from home during the pandemic are mainly employees who had regular previous telework experience (50%) compared to 25% of those who had no previous telework experience.

The share of those currently working from home was over 30% in all but four Member States (see Figure 13, next page). Nonetheless, the range of incidence between countries was wide (from 18% in Romania to 59% in Finland). The highest proportions of employees working from home were in the Nordic and Benelux countries, reflecting findings from the EWCS and LFS on the relatively high pre-outbreak prevalence of telework in these countries.

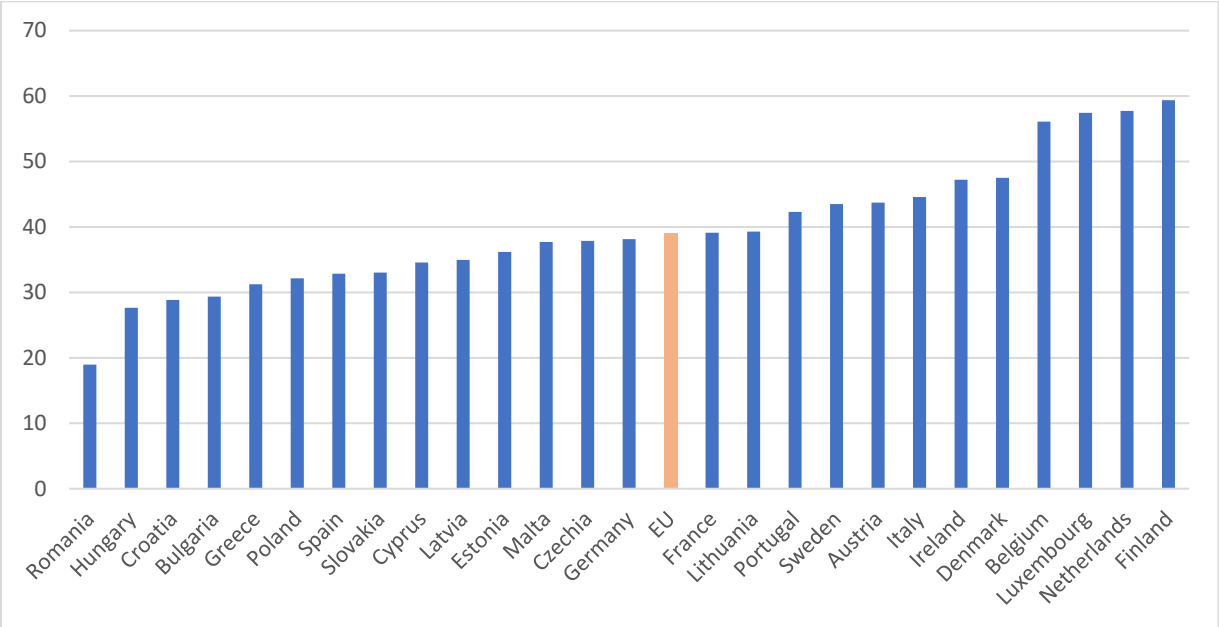
[4] The EWCS is a five yearly survey. By unlucky timing, the COVID-19 crisis has interrupted data collection of the seventh wave (2020) after around a quarter of the survey responses had been completed.

[5] The survey findings summarised here are principally from the following sources: the Mannheim Corona survey (for Germany; see Mohring et al, 2020), the COVID inequality survey (covering UK, USA and Germany; see Adams-Prassl et al, 2020) and Eurofound's online COVID-19 survey (covering EU27 + Norway + UK; see Eurofound, 2020). Some non-EU findings are also presented for broader context; US findings from a Federal Research Board supplementary survey carried out in April 2020 (FRB, 2020) and UK findings from a similar exercise in the same month (ONS, 2020).

[6] First findings were published on 7th May 2020. The survey was an open online survey, respondent recruitment was via snowballing and social media advertisements, the target population were those aged 18 and over in the EU member states and the UK. Data was weighted by age crossed with gender (in 12 age-gender combinations), urbanisation level (2 categories) and education level (2 categories) to reflect demographic composition in each country (Ahrendt et al, 2020; Eurofound, 2020). The survey asked respondents a variety of questions on living and working conditions during the COVID-confinement. Respondents were not asked to indicate occupation (ISCO) or sector (NACE) in which they worked but a follow up wave 2 of the survey planned for early summer 2020 will include such questions and will also include a specific module of eight questions on teleworking.

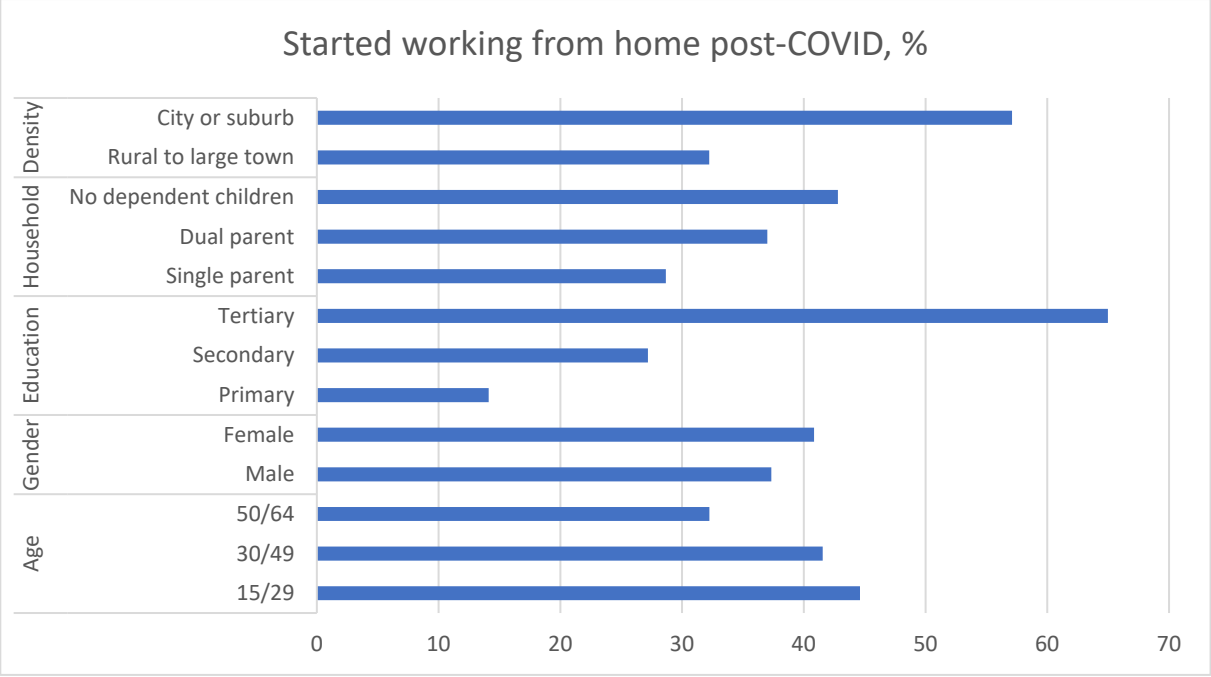
Women were somewhat more likely to report having started working from home post-outbreak than men (41% vs 37%, see Figure 14 below), whereas the opposite was true pre-outbreak, when 21% of men worked from home at least several times per month against 18% of women. The biggest rise in the prevalence of working from home was amongst younger employees supporting a narrative that the COVID-19 crisis has equalised access and neutralised at least provisionally the status-related dimension of access to telework.

Figure 13: Employees working from home during COVID-crisis, by country %



Source: *EF COVID survey. Note: no data for Slovenia.*

Figure 14: Working from home during COVID-19 crisis, EU27%: work and personal characteristics



Source: *EF COVID survey. Note: no data for Slovenia.*

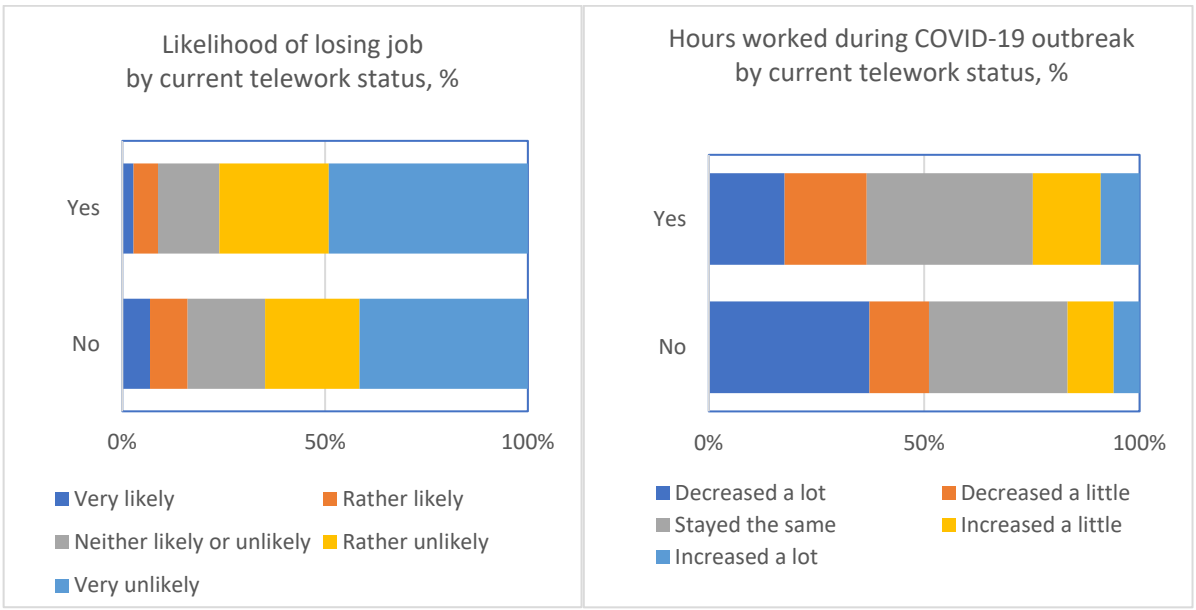
Employees with third-level degrees and those residing in cities or city suburbs were much more likely to work from home than others post-outbreak – something that was also observed before the outbreak.

With regard to employment-related variables, those who indicated to work from home at least several times a month already before the outbreak were less likely to have lost their jobs either permanently (1%, compared to 2%, see Figure 15 below) or temporarily (11%, compared to 20%) compared to those with no or very limited experience with working from home. Those currently working from home were less likely to have suffered a decline in working hours and were more likely to be confident about retaining their jobs over the next three months.

Probably for these reasons, those currently working from home reported a lower incidence of economic insecurity; were more likely to report being able to 'make ends meet' without difficulty (75%, compared to 49% of those not homeworking) or to have household finances that were no worse than they were in the previous three months (75%, compared to 58% of those not working from home).

Regarding working conditions, the survey provides limited coverage but confirms that blurred boundaries between work and home life are one potential downside of working from home. Nearly a half of those teleworking (48%) report working in their free time to meet work demands regularly (at least once or twice a week), over twice the share of those not teleworking (23%).

Figure 15: Teleworking as labour market buffer during crisis



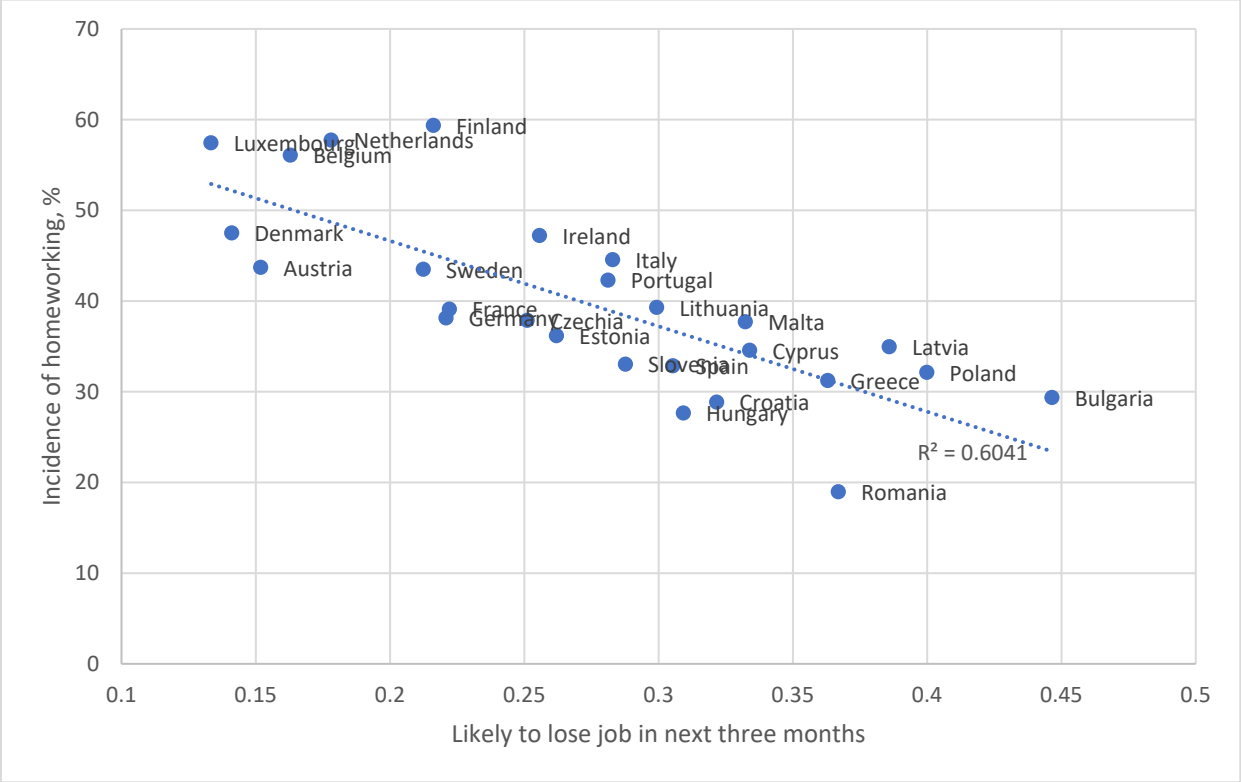
Source: *EF COVID survey. EU27 without Slovenia.*

Working from home therefore offered some buffer against employment or earnings loss. There are at least two effects at work here. Working from home has contributed to the resilience of employment by facilitating employment continuity in a context of widespread workplace closures; at the same time, the types of jobs in which homeworking is most prevalent – higher-skilled, knowledge based services work – tend to be those with more secure employment relationships linked to high levels of job-specific human capital.

Finally, homeworking appears to have mitigated negative employment effects not only at the individual level but also at the national level. In countries where more employees began working from home as a result of the pandemic, a smaller share reported temporary job loss, permanent job

loss or that their working time had decreased. Job insecurity was also lower in these countries (see Figure 16).

Figure 16: Higher incidence of homeworking, lower self-reported likelihood of job loss



Source: *EF COVID survey (author's elaboration). Likely to lose job scaled 0-1 where 0 = "very unlikely to lose job in next three months" and 1 = "very likely".*

German data from the **Mannheim Corona survey** (Mohring et al, 2020)[7] showed that at the end of March 2020, 26.5% of German workers were working from home. This had reduced to 22.5% by the week beginning 11 April. This compares to the figure of 12% (employees and self-employed combined) who regularly work from home, according to the German Federal statistical office data. There was no significant gender difference in the incidence of working from home at the end of March: 26% women, 27% men, in the initial two-week period but there was a modest differential in the later April wave (20.5% of women homeworking v 24.3% of men). During the same period, the take up of *kurzarbeit* (short-time work) had accounted for a much smaller share of the workforce (not more than 10%) so the first main finding was that homeworking was, initially at least, the dominant form of labour market adjustment to COVID-19 in Germany and numerically more important than short-time working.

According to the survey, those working from home were more likely to have higher-skilled jobs, a third level degree and higher earnings. Amongst those with higher education, the share of workers working from home was much higher (40%) than in those with secondary or basic education (11

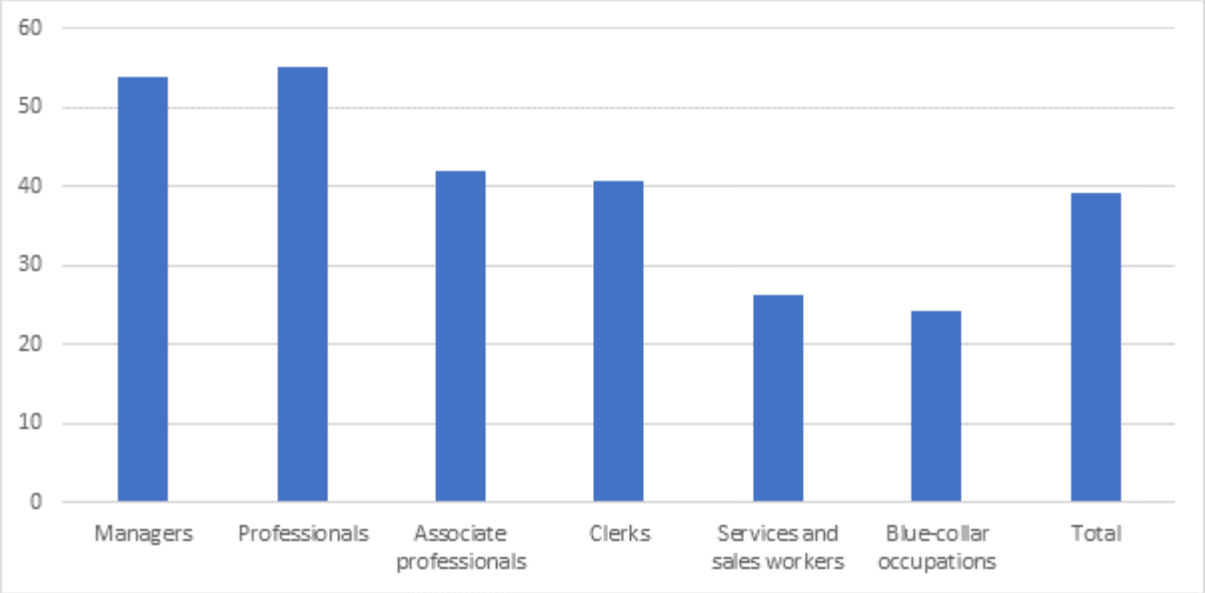
[7] An ad-hoc survey developed using the German Internet Panel to investigate some of the impacts of the COVID on work and living standards in Germany. Each week 3,500 working respondents are questioned. The sample for the employment analysis includes all adults who worked before the COVID-19 crisis (including self-employed and mini-jobbers). The survey began on March 20th and results covered here were published so far in four weekly instalments covering the first four weeks up to April 15th 2020.

and 6% respectively). Similar findings were found when breaking down by personal net monthly income with higher income earners (>2500 euro per month) much more likely to be homeworking (33%).

The sectors in which homeworking was most prevalent included IT and communication (59%), energy supply (54%), education (48%) and real estate (46%). Those least affected were: water supply and waste, health, hospitality and agriculture. There was a difference in the proportion of workers doing homework based on presence of dependent children in the household: 26.6% of workers with children compared to 20.8% of workers without. This suggests that the decision to homework probably relates partially to employer circumstances and partially to worker's household circumstances.

In a similar cross-national real-time survey [8]carried out in the USA, China, Japan, South Korea, the UK and Italy, **Belot et al** (2020) found that nearly four in ten employees had started to telework (39%, see Figure 17 below). The authors note that China has been particularly effective in moving its employees to teleworking arrangements. Despite the importance of manufacturing in the country, over half of Chinese employees reported teleworking (62%). The other highest shares were reported for employees in the USA (46%), Italy (42%) and the UK (30%) with lowest shares in Japan and South Korea.

Figure 17: Started to telework during crisis, by occupation %



Source: 6-country survey on COVID, see Belot et al 2020 for details (data kindly made available via Open Science Forum, https://osf.io/aubkc/; author's elaboration). Notes: pooled and unweighted data from six countries, employees only. Sub-sample of those occupations with at least ten observations (n=1424).

The chart above (Figure 17) describes the occupational distribution of those employees who had started teleworking during the COVID-19 lockdown period. In line with existing evidence, the highest shares were amongst managers and professionals where over half of employees had started to telework. Over 40% of associate professionals and clerical workers had teleworked while lower shares were reported for the sub-samples of services and sale workers and blue-collar occupations.

[8] Data collected between April 15 and April 23. Around 1,000 completed responses by country. Samples representative by age, gender and income. US respondents in four most populous states only – New York, California, Texas and Florida). Variable of interest: 'how did your work situation change in recent weeks as a consequence of the pandemic?" with answer categories: ' I do not work anymore', 'I started to telework', 'No change' and 'Other'.

The COVID real-time surveys commissioned by researchers at the **University of Oxford** (Adams-Prassl et al, 2020) were carried out across three countries to allow international comparison.[9] A particular focus of the survey was the impact of the share of work tasks that respondents report being able to carry out at home on the incidence of job loss. This proved to be a powerful predictor of job loss by sector and occupation accounting for over half of the variation in job loss in each country. The main finding of relevance for our analysis is the extent to which self-reported 'homeworkability' offered protection against job loss, notably in the US and UK.

The **US Federal Reserve Board** (FRB, 2020) carried out a supplemental data collection in April 2020 to its 2019 survey of the economic well-being of US households, in order to "understand recent financial conditions and how circumstances for families have changed" post-COVID. With caveats related to small sample size, it found that more than half of US workers (53 percent) did at least some work from home in the last week of March, and 41 percent did all their work from home. By comparison, in October 2019, 7% of employees worked from home. Workers with higher levels of education were more likely to work from home. 63% of workers with at least a bachelor's degree worked entirely from home. Among workers with a high school degree or less, 20% worked entirely from home. There has been a widening differential of homeworking incidence by completed educational level post-outbreak (FRB, 2020).

The **UK Office of National Statistics** (ONS, 2020) ran weekly waves of its (normally monthly) Opinions and Lifestyle survey to cover emerging developments during the COVID-19 crisis from April 2020. Again with caveats related to limited sample size, the main findings of interest for this paper were the broad take up of working from home during the crisis – in no region did it account for less than a third of workers - and its regional concentration in the capital city region, London, where 61% of workers reported working from home in April. A large majority of those working from home worked exclusively from home (84%) and this was even more the case in the London region (87%). Not coincidentally, London was also the region most affected by COVID-related mortality, with the highest population density, greatest reliance on public transport and the highest share of employment in service sectors where working from home was a reasonable alternative.

Irish data from a national online survey conducted by the **National University of Ireland Galway and Whitaker Institute** (McCarthy et al, 2020) was addressed specifically to those working from home post-outbreak.[10] For this reason, it adds less to our knowledge of the incidence of working from home but it does offer interesting data on its qualitative aspects. Just over half of respondents (51%) had never worked from home before the COVID-19 crisis. The majority (87%) of respondents said they had the equipment needed to work from home but poor physical and ergonomic workspace was indicated as one of three key challenges of working from home. The other challenges most frequently cited were not being able to 'switch off' from work and greater difficulty in collaborating / communicating with colleagues. The remote working experience was however assessed favourably in most respects. 83% of respondents indicated that they would like to work remotely after the crisis is over (12% on a daily basis, 42% several times a week, 29% several times a month) while only 16% indicated that they would not want to continue working remotely. Those aged 31-40 were most likely to want to work remotely after the crisis while the highest proportion not wanting to work remotely was amongst older workers (60+, though even in this group this was the minority – 26%).

[9] Data was collected by a professional survey company in Germany (one wave) and the UK and USA (two waves) in late March and early-mid April 2020. Sample sizes were c. 4-5,000 in each country per wave.

[10] Online survey from 27 April to 5 May 2020 (n= 7,241).

In summary, each of the real-time survey sources cited confirms that for the advanced economies covered the incidence of working from home increased dramatically in reaction to the COVID-19 public health measures. The share of workers reporting working from home in advanced economies ranged anywhere from one in five workers up to three in five in some regions or countries with a strong knowledge-based services share of employment or a recent tradition and relatively high prior prevalence of teleworking. Much of this increased incidence of working from home is likely to have been intensive and exclusive – in contrast to teleworking before the outbreak, which was predominantly occasional. The incidence amongst EU member states varied broadly but largely reflected pre-existing differences, with lower levels of teleworking in Eastern and Southern member states and higher levels in the Nordic and Benelux countries. Those with third-level qualifications and with higher income were most likely to be homeworking and there was some evidence that the differentials by qualification levels had widened post-COVID. Teleworkability provided a significant buffer to the labour market shock of COVID-19, at individual and aggregate level, across a number of dimensions – job loss, hours worked, income and job security. The most frequently-cited downside of teleworking post-outbreak was the inability to "switch off" from work, though the main assessment from a worker perspective appears to have been positive, with a majority of those working from home during the outbreak feeling positive about extending the arrangement after the crisis.

What jobs can be done from home – a tasks approach

The previous section described the available evidence on the prevalence of telework in the European Union before the outbreak of COVID-19. However, the nature and circumstances of telework changed drastically during the crisis, because of a generalised lockdown of social interaction and economic activity to prevent exponential growth of contagion across Europe.

As discussed in Fana et al. (2020), some economic activities that necessarily involve a high level of face-to-face interaction with the public were forcefully closed (mostly hospitality, leisure and personal service activities). But some other activities, whether they implied social interaction or not, could be maintained even in the harshest lockdown conditions via telework. Indeed, most European governments explicitly requested that whenever possible, people should telework rather than physically go to their employers' premises, until the pandemic is controlled.

Early data from real-time surveys reviewed in the previous section suggests that European companies and governments expanded telework on an unprecedented scale. The speed of transition to mass telework raises the question of how many jobs of the pre-outbreak economy can be done remotely, and if so, how effectively they can be carried out.

In this section, we provide an explicit theoretical foundation to classify occupations based on whether they can technically be performed remotely. We develop an index of **technical teleworkability**, based on an existing conceptual framework and taxonomy of tasks for occupational analysis (Fernández-Macías and Bisello, 2020), and using with data form European occupational surveys. To account for the fact that many jobs involving a high degree of social interaction are more difficult to carry out remotely, even if it is technically possible to do so, we also develop a complementary index of **social interaction** of occupations.

Our approach is comparable to previous efforts to measure the potential to offshore different occupations (Blinder, 2009), or to automate them (Frey and Osborne, 2017). More recently, Dingel and Neiman (2020) used a similar approach to measure the share of jobs that can be done from home in the United States. However, our contribution differs from Dingel and Neiman (2020) by having an explicit theoretical foundation, and in some crucial details of implementation, discussed further in Box 5.

The theoretical underpinning and the methodology to generate indices of *technical teleworkability* and *social interaction* are described in the following subsections, with additional details presented in the annex. The next section links these estimates to employment data for the EU, to better understand which occupations are teleworkable, and how the share varies across countries. The annex reports the full table of values of the teleworkability indices for all 3-digit ISCO occupational codes.

Teleworkability as a technical feasibility: a conceptual framework for occupational analysis

Our approach is based on the framework and taxonomy of tasks for occupational analysis developed in Fernández-Macías and Bisello (2020). This framework understands the dual nature of work both as a transformative process operated on different objects, and as a collaborative process that requires coordination. Analytically, the framework describes any work activity along three different axes:

1. **task contents of work**, which classifies tasks according to the object on which they operate and the type of transformation process involved, and at the highest level it differentiates between
    a. **physical tasks**: operating on things,
    b. **information-processing (or intellectual) tasks**: operating on information or ideas,
    c. **social interaction tasks**: operating on social relations.
2. **methods of work**, which reflect the forms of *work organisation* used to coordinate a particular productive process, and which can be broadly characterised by the levels of teamwork, autonomy, and routine in the work process.
3. **tools of work**, which refer to the *technologies* used in the production processes.

Building on this framework, we define **teleworkability** as *the technical possibility of providing labour input remotely into a given economic process*. We say "technical possibility" to emphasize that teleworkability depends on what types of task content can be remotely provided with the available technology. Whether teleworkability – as a potential – is actually put in practice or not in a given work process will also depend on the methods of work (namely work organisation), and the specific tools (technologies) used at work. These are discussed later on in this section. For the moment, we will focus on whether the different types of task content – physical, information-processing, and social – are compatible with telework.

Information-processing tasks – operating with ideas or information – are arguably the most suited to telework. The Digital Revolution has vastly expanded our ability to transmit, manipulate and store information (Brynjolffson and McAfee, 2017, Fernández-Macías, 2018). Any information that can be digitally encoded without loss can be perfectly transmitted to any part of the world almost instantly, which means that any task aimed at operating with encoded information (verbal, numeric or of any other type) can be performed remotely without any loss in a technical sense.

Social tasks can increasingly also be provided remotely, but often with a loss of quality in the service. Digital communications have also expanded massively the possibilities for remote social interaction. Already analogue forms of remote communication such as mail or landline telephones allowed long-distance verbal interaction, but the very significant limitations in the amount of information that could be transmitted (and its speed) made them very inefficient compared to face-to-face communication.

In contrast, digitally encoded visual and auditory information transmitted via the internet (as in a videoconference) allows for a very efficient remote social interaction, as long as it is a form of social interaction does not require actual physical contact. There is still significant information loss compared to face-to-face social interaction: even in the most flawless videoconference, there are small lags or informational noise that can be quite disruptive, and also many non-verbal or connotative clues are likely to get lost (for instance, see Schoenenberg et al., 2014). From the taxonomy of social interaction tasks of Fernández-Macías and Bisello (2020), we can list some categories of social tasks that can be remotely performed but with a loss of quality: teaching, selling, negotiating, caring, coordinating.

Finally, physical tasks – which involve the physical operation with things or people – are the ones where remote labour input remains most difficult. Although there have been important advances in recent years in the fields of telepresence and telerobotics (for a discussion, see Baldwin, 2019), being able to remotely manipulate objects with a level of precision similar to actual presence is still beyond the capabilities of even the most advanced technologies. Therefore, the physical task content of any occupation will determine whether it can be performed remotely or not. Any job that requires significant physical contact with things or people will not be amenable to telework.

Therefore, following the framework of Fernández-Macías and Bisello (2020), we can differentiate three big categories of tasks by their teleworkability given the state of existing technology:

- **physical tasks**, which can generally not be provided remotely with existing technologies and thus are the real bottleneck for the teleworkability of occupations;
- **social interaction tasks**, which unless they require physical contact can also be provided remotely but with a significant loss of quality;
- **information-processing tasks**, which can in general be provided remotely with hardly any loss and which can be easily identified by their use of computers.

As discussed in Fernández-Macías and Bisello (2020), in practice, the vast majority of jobs incorporate a mix of physical, information-processing, and social interaction tasks. In advanced service economies such as those of the EU, the predominant type of task content in the labour market is social interaction, followed by information-processing and last (with the lower prevalence) physical task content. But since physical tasks are the real bottleneck of the teleworkability of occupations, we can operationalise it into a negative and binary indicator of **technical teleworkability**: if a job has a significant amount of task content that requires the physical manipulation of objects or people, then we can classify it as *not* teleworkable. Dingel and Neiman (2020) also use a binary and negative approach to measure teleworkability (though including other types of task content, see Box 5 for more details).

For the much more common social interaction tasks, we can develop a negative and continuous indicator that complements the index of technical teleworkability. As previously argued, as long as a social interaction task does not require direct physical contact (in which case it would fall in the *physical* category), it can in principle be carried out remotely *but with a decline in quality*. For a given job, this decline in quality associated with telework can be approximated by the amount of (non-physical) social interaction required. For instance, a psychotherapist job is almost entirely composed by social interaction task content, but it does not require physical contact: therefore, the job can be classified as teleworkable according to the logic of the previous paragraph, adding the further qualification that in this case, telework implies a significant loss of quality in the provision of the service.

To operationalise this qualitative assessment into a continuous indicator for occupations, we can use indicators of social interaction tasks at work (for instance, measuring the share of total working time spent on social tasks) and aggregate them into an index under the assumption that *the more social interaction tasks the lower the quality of the service provided if it is via telework*.

Thus, a value of 0 in this index (meaning no social interaction tasks) would be the most teleworkable, and a value of 1 the least, with values in between reflecting the degree of social interaction tasks present in the job. However, it is important to note that this index may not be interpreted in terms of teleworkability on its own, but only in combination with the physical teleworkability index previously discussed. This is because, as already argued, physical interaction task content is the actual bottleneck, and thus a value of 0 in that index implies absolute non-teleworkability; if a job has a value of 0 in terms of physical teleworkability, the value of social interaction is irrelevant. Only when a job is physically teleworkable can we use the social interaction index to qualify its teleworkability as continuous attribute: a physically teleworkable job with a lot of social interaction is less amenable to remote provision than a physically teleworkable job with no social interaction.

Finally, since physical and social task content determine negatively the teleworkability of a given job, the extent to which the same job involves information processing is ultimately irrelevant, even if information processing tasks are generally teleworkable. As we will discuss in the following section, we will only use a proxy indicator of information processing tasks (use of computers at

work) as complementary information, to validate the results of our main variables of teleworkability (based in physical and social interaction task content, as previously explained).

One may be tempted to integrate the physical and social indicators into a single index, so that a value of 0 in the resulting composite index reflects no teleworkability (based on the physical content of the job), a value of 1 reflects the highest teleworkability (no physical or social interaction tasks), and values in between reflecting (in reverse) the degree of social interaction tasks for non-physical (and thus technically teleworkable) jobs. However, in practice, it is useful to keep the two indices separate because they convey more information, as illustrated in the next sub-section.

Constructing indices of teleworkability

To construct the teleworkability indicators of physical and social interaction, we relied on existing European data sources that measure the task content of specific occupations with some level of detail. In particular, we used the Italian Indagine Campionaria delle Professioni, and the European Working Conditions Survey.

The Italian Indagine Campionaria delle Professioni (ICP) is a survey of occupations conducted by the National Institute for Public Policy Analysis (INAPP) in collaboration with the Italian National Statistical Institute (ISTAT). It follows closely the structure of the American O*NET database, and thus incorporates very detailed information on tasks, skills, work contexts and organisational characteristics, collected at the 5-digit level of occupations (Codici Professionali, or CP). There are two waves currently available (2007 and 2012), the most recent being the one used in this paper. In total, 16,000 Italian workers were interviewed, representative of sectorial, occupational and geographic heterogeneity (see also Cetrulo et al. 2019). On average, 20 workers per each 5-digit occupation were interviewed face to face for around one hour. The scope and depth of the survey, at the level of detailed occupations, makes it uniquely able to measure in the content of work across occupations.

We chose to use this source over the data of American O*Net because we believe it better reflects the characteristics of occupations, tasks, and work organisation found in the European economy. In recent work adapting the Dingel and Neiman approach to the Italian labour market, Cetrulo et al (2020) have made a similar use of the ICP to that in this paper estimating that 30% of Italian workers are employed in teleworkable jobs.

The European Working Conditions Survey (EWCS), conducted by Eurofound, focuses on the conditions of work and employment of Europeans. It is representative of the entire EU employed population, and conducted every five years since 1991. The wave we use in this paper (2015) covered 35 countries and nearly 44,000 interviews (between 1,000 and 2,000 interviews per country). It was also conducted face to face, in the homes of the respondents, for an average duration of about 45 minutes.

Technical teleworkability index

From these surveys, we identified variables consistent with the approach to teleworkability presented in the previous pages. First, for tasks involving the physical manipulation of objects, people, or machinery, we identified the following seven variables:

Table 1: Variables selected for technical teleworkability index

Variable	Scale reported	Unit	Source
Manual Dexterity	Importance (0-100)	CP 5 digit	ICP
Finger Dexterity	Importance (0-100)	CP 5 digit	ICP
Performing General Physical Activities	Importance (0-100)	CP 5 digit	ICP
Handling and Moving Objects	Importance (0-100)	CP 5 digit	ICP
Inspecting Equipment, Structures, or Material	Importance (0-100)	CP 5 digit	ICP
Operating Vehicles, Mechanized Devices, or Equipment	Importance (0-100)	CP 5 digit	ICP
Lifting or moving people	Frequency (7-point scale)	ISCO 3 digit	EWCS

All of these tasks involve the direct and physical operation with things or people, generally requiring strength, dexterity and hand-eye coordination. Although there are experimental technologies that may eventually achieve a breakthrough in the remote provision of this kind of labour input (for instance, remotely controlled robots), as of today these technologies are very far from being widely available. Therefore, these types of task content cannot be performed remotely.

Once these variables were identified, we proceeded to standardise and aggregate them.[11] In the case of EWCS, the original 7-point measurement scales were translated into a continuous scale of 0-100 (from lowest to highest physical task intensity in the occupation). The data of ICP, originally collected on a 7-point scale in surveys, was already reported on a 0-100 scale.

In the case of ICP, for each 5-digit occupation, whenever any indicator of the six physical task variables was above a threshold of 40, we classified the corresponding occupation as *not teleworkable*.[12] This is based on our understanding that if respondents from a given occupation report that even one physical task is important for their job, then the job in question cannot technically be carried out remotely. However, setting a numeric threshold for what "sufficiently important" means is necessarily an arbitrary choice. Based on the distribution across occupations of the raw response values of the importance scores, we decided on a value of 40 on the 100-point scale as a threshold for all variables from ICP and EWCS, with a few minor ad-hoc adjustments commented in greater detail in the Annex.

As a result, each of the 798 5-digit occupations in ICP was classified as either technically teleworkable or not. Then, to allow for international comparisons, we aggregated the occupational classification from 798 5-digit *Codici professionali* (CP) units into 121 3-digit ISCO units, using the official mapping published by Istat.[13] Since 3-digit ISCO groups may occasionally bring together occupations with different levels of physical interaction, when aggregating from 5-digit CP into 3-

[11] The code for constructing the teleworkability indicators is available at: https://github.com/m-sostero/telework-occupations

[12] For instance, the occupation 3.1.1.2.0 (*Tecnici chimici*, belonging to ISCO group 311 *Physical and engineering science technicians*) received the following scores: 29.8 for manual dexterity tasks, 32.1 for finger dexterity, 15.5 for performing general physical activities, 40.5 for handling and moving objects, 54.8 for inspecting and 10.0 for operation with vehicles or equipment. Since the scores were above the threshold of 40 in "handling and moving objects" and in "inspecting equipment, structures or materials", the occupation *Tecnici chimici* was classified as not teleworkable.

[13] https://www.istat.it/en/files/2013/07/la_classificazione_delle_professioni.pdf.

digit ISCO we weighted the binary values of the teleworkability index based on the relative share of employment in each 5-digit occupation among the 3-digit group, based on recent Italian Labour Force Statistics. Thus, the value of teleworkability of a 3-digit occupation reflects the employment-weighted share of 5-digit occupations within it that are teleworkable.[14]

Finally, only for the variable "lifting or moving people" from EWCS, we computed the average value for workers at the level of ISCO 3-digit codes. As for variables drawn from ICP, we classified occupations as not teleworkable if the value was above a threshold of 40.

The result is a continuous variable measuring the technical teleworkability of each 3-digit occupational code, ranging from 0 (the occupation is fully non-teleworkable) to 100 (the occupation is fully teleworkable). Values between 0 and 100 correspond to 3-digit occupational categories which incorporate some more detailed 5-digit occupational codes which are teleworkable and some which are not.[15]

Social interaction index

We constructed a continuous index of social interaction task content, which is intended as a qualification of the assessment of technical teleworkability of the previous index. As explained in the previous section, any occupation which is totally or partially teleworkable from a technical perspective can be also be assessed in terms of how socially comfortable and efficient the remote provision of labour will be, as a function of the degree of social interaction involved. For constructing this second indicator, we used the following five variables, all of them from ICP.

Table 2: Variables selected for social interaction index

Variable	Scale	Unit	Source
Selling or Influencing Others	Importance (0-100)	CP 5 digit	ICP
Training and Teaching Others	Importance (0-100)	CP 5 digit	ICP
Assisting and Caring for Others	Importance (0-100)	CP 5 digit	ICP
Performing for or Working Directly with the Public	Importance (0-100)	CP 5 digit	ICP
Coordinate the work and tasks of others	Importance (0-100)	CP 5 digit	ICP

These five variables cover all of the five main dimensions of social interaction task content of the framework of Fernández-Macías and Bisello (2020). As in the variables measuring physical task content, the five variables were originally measured in a 5-point importance scale, which was converted into a continuous 0-100 scale. Then, for each 3-digit occupation (in this case, there was no need to aggregate at the 5-digit level), we computed the arithmetic average of the two highest

[14] Following with the previous example, the final value of teleworkability for ISCO-3 digits code 311 (*Physical and engineering science technicians*) is 0.7 (in a scale of 0-100), because 13 of the 14 5-digit occupations within 311 are not teleworkable, and the one that is teleworkable (*Disegnatori tessili*) accounts for less than 1% of employment in that code.

[15] For instance, ISCO 3-digit code 221 (Medical doctors) has a value of teleworkability of 39.2. This is because within that code there are six 5-digit occupational codes: general practitioners, specialists, surgeons, pathologists and radiotherapists. While GPs, surgeons, pathologists and radiotherapists are classified as not teleworkable, specialists are teleworkable because none of their physical task indices go beyond 40. Since 39.2% of the 3-digit code 221 corresponds to the teleworkable occupation of medical specialist, that is the value we assign to ISCO code 221.

scores in any of the 5 social interaction variables. The reason for this is that it is impossible for any individual job to involve all the five different types of social task content simultaneously. However, we wanted to assign higher values to occupations that require intense social interaction in two types of social tasks, which is perfectly feasible.

Additional indices

Finally, we constructed two additional indicators which are only used for secondary purposes (to check the plausibility of the two main indicators, and to provide additional context). These are:

- **Computer use** (from EWCS): a variable which measures the approximate amount of time spent "working with computers, laptops, smartphones, etc". As with the other variables, the original 7-point frequency scale has been translated into a 0-100 scale reflecting the approximate percentage of time using computers at work, and then average scores by 3-digit ISCO codes have been computed.
- **Pre-COVID19 work at home** (from 2018 European Labour Force Survey): this is an indicator measuring how often the respondent works at home. The original 3-point scale has been rescaled to 0-100, assigning a value of 100 to those that "usually" work at home, 30 to those that "sometimes" work at home, and 0 to those that "never work at home. The scores were finally averaged by 3-digit ISCO codes.

Advantages and limitations of the methodology

The approach to construct the teleworkability indices described above is intended to make a plausible classification of occupations in terms of whether they can technically be performed remotely. Following the framework and taxonomy of tasks for occupational analysis developed in Fernández-Macías and Bisello (2020), and considering the current state of technology, we argue that the crucial determinant of whether a certain job can be done remotely or not the relative importance of physical tasks – those involving physical interaction with objects or people. However, the same framework also considers work organisation and technology as crucial aspects of the task profile of occupations, and certainly these are aspects that can also affect the actual incidence of telework in particular cases.

The methods of work relate to organisational (and legal) factors. The ways in which work is allocated, coordinated and supervised in an organisation surely matter for the existence of telework options. Even enterprises operating in the same sector, or similar public administrations in different countries can organise work in very different ways, which will have an impact on how much work can be done remotely. With the data at our disposal, we cannot easily measure organisation structures and cultures across different types of European companies. Moreover, as the evidence on the current expansion of teleworking presented at the end of the first section shows, work organisation practices and regulation are ultimately contingent on the circumstances, and can change quickly or be suspended in case of necessity. For instance, as previously mentioned, telework is normally much more frequent for managers than for secretaries, but this likely reflects less technical feasibility than hierarchical position. The technical feasibility of remotely providing their typical task content is probably similar for both categories of workers, but managers typically enjoy more autonomy and are subject to less monitoring of their work effort than secretaries. In this paper, we are mostly concerned with estimating the technical feasibility of telework across different occupations.

A similar reasoning holds for tools of work, notably the type of information and communication technology (ICT) used at work. The specific technology also certainly matters for telework, as digital communication tools shape different methods of remote work, including collaboration and

teamwork, as well as setting the level of autonomy, latitude or supervision of workers. However, every organisation chooses and uses its technology infrastructure based on its own routines and needs; it is thus difficult to observe how technology affects work organisation in aggregate at the European level. The ICP and EWCS data only describe differences in the use of technology at a superficial level, for instance by focusing on the use of e-mail, a well-established form of communication, which is not particularly informative of teleworkability in itself. Another limitation of the data available is that we cannot account for international differences in the digital skills and use of technologies by different occupations. Whatever detailed data we have on the matter relates to Italy in 2012, which is unlikely to correctly represent the state of technology in European workplaces in 2020.

The operationalisation of the technical teleworkability index inevitably involves arbitrary methodological choices. In particular, for analytical simplicity we decided to implement technical teleworkability as a binary indicator (originally defined for CP 5-digit occupations). This implies setting a hard threshold on the values of the underlying physical task indicators reported in the ICP survey, which we set at 40 on a 100-point scale. In the majority of cases, the resulting classification, reported in Annex 2, is consistent with intuition and anecdotal evidence on whether different occupations have been able to telework during the lockdown. Unsurprisingly, there are also some exceptions of occupations that are classified as teleworkable when experience suggests they should no bet, or vice-versa. This is especially the case when aggregating the scores from the original CP 5-digit occupations that the ICP survey measures, to more diverse ISCO 3-digit occupation groups used for further analysis. Upon closer inspection, many of these classifications follow quite consistently from the values of the physical task indicators of the underlying occupations. Partially teleworkable ISCO 3-digit groups, with values of technical teleworkability between 0 and 1, reflect this heterogeneous composition of some 5-digit occupations that can telework, while others cannot, at least in terms of their relative weights in the Italian labour force. In two cases, we decided to re-classify some occupations, on the ground that the physical interaction variables reported in the survey fell slightly below the threshold, but did not seem to accurately reflect the task profile of those occupations. This was notably the case of cashiers, which reported (implausibly, in our view) to have limited physical interaction, including with objects, in their job. We also reclassified child care and teacher's aides as not teleworkable, on the same grounds. We comment the classification and discuss all such cases in Annex 1. However, these ad-hoc adjustments only concern a tiny minority (2) of the occupations classified (798 at 5 digits, 121 at 3).

In general, we should note that our classification methodology relies on a snapshot of the nature of work taken before the COVID crisis and lockdown, and is especially reliant on detailed data from a single country. In general, the tasks, methods and tools of work varies across countries and changes over time, although existing evidence suggests that the cross-country variation in task content (the core of our classification) is much smaller than in task methods and tools (Fernández-Macías, Hurley and Bisello 2016). The unprecedented circumstances and exigencies of the lockdown have probably accelerated these changes, forcing companies and workers to adapt. Some forms of work organisation practices that were rooted in office work have probably been suspended, at least temporarily. The tools of work, notably corporate ICT equipment, have also been adapted or expanded to enable mass remote connection. It is also very likely that workers, making a virtue of necessity, had to change the composition and relative importance of tasks they normally perform in their occupations to adapt to the circumstances. No doubt a minority of resourceful people in resilient organisations were able to change the way they work radically, but existing evidence suggests that among the three axes describing work, the task contents of work are more constant in the short term, while methods and tools are more contingent or flexible (Fernández-Macías, Hurley and Bisello, 2016).

Box 5: Comparing the methodology of teleworkability with Dingel and Neiman (2020)

Dingel and Neiman (2020) provided estimates of the share of the US population that can work from home, based on data from the American occupational database O*NET. From this survey, which collects detailed standardised information on what workers do in different occupations and is the model of the Indagine Campionaria delle Professioni used in this work, they identified a number of variables to infer whether the associated occupations could be performed from home or not, from the sections on "Work context" and "Generalised work activities".

The most important difference between our approach to identify the teleworkability of occupations and that of Dingel and Neiman is the theoretical justification. Whereas we try to anchor our teleworkability measure to a tasks framework developed for occupational analysis, and provide a detailed justification for the items included and the operationalisation, Dingel and Neiman do not provide much justification for the variables they pick and the method of coding and aggregating them. In our view, an explicit theoretical anchor and justification helps to link our findings with the previous literature and to make a better interpretation and discussion of the broad implications.

As in our technical teleworkability index, Dingel and Neiman define teleworkability in general in a negative and binary way: some specific values of the identified variables are considered as incompatible with telework, and thus they are used to code the associated occupation as non-teleworkable. For instance, if the average worker in a given occupation uses email less than once a month, the occupation is coded as non-teleworkable.

However, Dingel and Neiman do not provide a general logic or a theory for the selection of variables or the conditions that define teleworkability: in a methodological annex, they just list the O*NET variables and thresholds used. In total, they used 15 variables measuring very different aspects of work – negative indicators of teleworkability as previously mentioned – which we can classify (our criteria, not theirs) in four groups:

- Physical work content: performing general physical activities, walking or running, handling or moving objects. Here we can also include a series of variables that refer to the handling and operation of machinery: controlling machines and processes, operating vehicles and equipment, repairing and maintaining mechanical or electrical equipment, and inspecting equipment, structures or materials.
- External conditions of work: work outdoors, wearing protective equipment, exposure to burns or bites, exposure to disease or infection.
- Social interaction at work: performing or working directly with the public, dealing with violent people.
- Use of communication technology: use of email.

Looking at the list above, we can infer some criteria implicitly used by Dingel and Neiman for identifying the teleworkability of occupations. According to the number of related O*NET variables used (8), it seems that performing a significant amount of physical or manual activity is the most important criteria to determine that an occupation cannot be performed remotely. A second criterion would relate to physical exposure to external conditions at work (3 variables); a third to face to face social interaction (2) and a final criterion would be the use (or lack of it) of a specific communication technology – email.

As previously argued, this seems reasonable and may work as a practical approximation to identify the teleworkability of occupations, but it also seems somewhat ad-hoc, and is not very clearly justified. For instance, why using only one variable related to the use of communication devices, and why choose email, when telephone is also considered in O*NET? Why include a variable specifically about dealing with violent people, when that can surely be also done (and more comfortably so) by phone or other remote means of communication? Why include so many variables measuring operation with machines? What is the underlying theory or conceptual framework for characterising the teleworkability of occupations?

In general, they include many variables specifically related to the (manual) operation with machinery, which in our view can be problematic: although it is probably true that nowadays most machine operation is still carried out manually, an increasing amount of machinery incorporates digital connectivity and sensors which are specifically designed to facilitate remote operation. Dingel and Neiman also use variables measuring external conditions of work (work outdoors, wearing protective equipment, etc.), which may work well as a proxy for physical task content – most work outdoors is of a physical nature, in most cases because it implies interaction with the physical environment, as in gardening or construction – but in itself seems unrelated to teleworkability.

Although Dingel and Neiman also take social interaction into account, in this respect our approaches differ more significantly: in this case, they also apply a negative and binary approach that in our view does not quite fit with social interaction. As previously argued, we believe social interaction affects the quality rather than the strict feasibility of remote work. They only use two indicators of social interaction tasks, one of which does not even fit in our view (dealing with violent people, which is not something that can only be done face to face). Finally, Dingel and Neiman include one indicator of use of email at work that seems to imply a different approach to teleworkability – based on technology use rather than task content – which we avoid because in our view ICT use is just too pervasive to be used for identifying teleworkable jobs.

Other recent papers approach this issue in slightly different ways. Leibovici et al. (2020) focus only on physical proximity to people: based on O*NET variables that assess the extent to which the job requires workers to perform tasks in close proximity to other people, they classify occupations into low, medium and high contact-intensity occupations. Mongey et al. (2020) combine the two previous approaches by Dingel and Neiman (2020) and Leibovici et al. (2020) to construct two indicators of teleworkability: “work from home” and “physical proximity”. Their analysis shows a strong negative correlation between these two indicators. However, this also highlights some important outliers, such as education jobs which require high physical-proximity but exhibit few features that would prevent working from home, suggesting that under strict confinement rules these jobs would be teleworkable but would have to adjust to comply with the social distancing measures. Pouliakas and Branka (2020) developed a COVID-19 social distancing risk index based on physical proximity and digital intensity to identify individual and job factors most likely to be impacted by social distancing measures, and found that a majority of the EU-27 workforce is at varying degrees of risk of disruption.

What jobs are teleworkable?

This section presents first some descriptive analysis of the teleworkability and social interaction indices for ISCO 3-digit occupation groups and their correlations with computer use and previous experience with telework. It then presents EU-level estimates on how many and what types of jobs are teleworkable in Europe, based on these indicators and 2018 EU Labour force Survey Estimates.

Teleworkability indices of occupations

Figure 18 shows the values of technical teleworkability and social interaction indices for the 121 ISCO 3-digit occupation groups. The figure is divided in three panels:

The panel on the left-hand side shows the values of social interaction for all the occupation groups that were classified as fully non-teleworkable. These ISCO 3-digit occupation groups are entirely composed of CP 5-digit occupations that involve a significant amount of physical task content (above 40 in at least one of the 7 specific task indicators used), and thus we consider that they cannot be carried out remotely. Most of these occupations have relatively low values of social interaction (the points cluster at values below 50 in the vertical axis), although there are some exceptions. Nurses and midwifes, street and market salespersons, childcare workers and street vendors are examples of occupations that are not teleworkable but involve very high levels (around or above 75 points in our index) of social interaction. But at the bottom half of the panel we see the bulk of non-teleworkable occupations, including most manual occupations in manufacturing, transport and mining. These are occupations that cannot be teleworked because they incorporate a very significant amount of manual labour, but they involve very little social interaction task content (beyond interactions with co-workers).

The panel in the middle of the chart shows the values of technical teleworkability and social interaction for occupations that are partially teleworkable, meaning that the ISCO 3-digit group encompasses some CP 5-digit occupations that are teleworkable and some that are not. As already implied in the left-hand panel, there is some positive correlation between the technical teleworkability and social interaction indices, because occupations with high teleworkability tend to involve more social interaction (the points tend to move from the bottom left to top right quadrant). Occupations with low teleworkability and low social interaction are machine operators, control technicians and elementary workers. On the opposite quadrant (high teleworkability, high social interaction) we find teachers, doctors, travel attendants, managers in services. There is also an interesting cluster of occupations with high teleworkability and low social interaction, such as clerical support workers, life science technicians and ICT operators.

Finally, the panel on the right-hand side shows the social interaction scores of all the occupation groups classified as fully teleworkable. Again, the positive association between technical teleworkability and social interaction is confirmed, because there are more occupations above than below the middle value of social interaction (50). At the top, we see fully teleworkable occupations that involve a lot of social interaction, including teachers, legal associate professionals, managing directors, legislators, sales agents and brokers. Below a score of 50 in social interaction task content, we see many clerical occupations, some ICT and technical service professionals, authors, journalists and linguists.

Thus, Figure 18 serves as a good summary of our assessment of teleworkability across detailed occupational categories in Europe, based in a framework that focuses on the physicality of jobs and the degree of social interaction. Since the horizontal axis reflects physical teleworkability and the vertical axis reflects social interaction, we can also analyse the figure by splitting the points in four quadrants:

- The bottom right quadrant would include the most easily teleworkable jobs, because they involve very little physical task content and very little social interaction. Examples of

occupations in this quadrant are: clerks, ICT professionals, authors, secretaries. It is interesting to note that some of these occupations, as we will discuss later, did not display particularly high levels of telework before the COVID-19 crisis (although they are likely to be all teleworking now). As hinted in previous pages, this is probably because telework before COVID-19 tended to be at least as driven by hierarchy (telework tended to be a privilege of managers and professionals) as by technical feasibility.

- The top right quadrant includes jobs which are physically teleworkable but which require a lot of social interaction, and thus the remote provision of labour is likely to be less than optimal or comfortable (both for the worker and the public or client). Here we find many types of managers and professionals, as well as teachers. These are often the jobs with higher levels of telework prevalence (in most cases occasional, though) before the COVID crisis.
- The top left quadrant includes jobs which are not technically/physically teleworkable and also require a significant amount of social interaction. In our assessment, these would be the least teleworkable jobs of all. This category includes nurses, salespersons, sports and fitness workers, childcare workers.
- Finally, the bottom left quadrant includes jobs that are not technically teleworkable because they require a significant amount of physical interaction with things or people, but they require very low levels of social interaction. Thus, the bottleneck in this case is purely technical, and a breakthrough in telerobotics for instance could make these jobs teleworkable in the future. It is interesting to note also that these jobs are probably the most automatable, since existing robotic technology can perform physical manipulation tasks with a high degree of precision (especially if they are repetitive and standardised; see Fernández-Macías et al 2020).

It is also useful to compare our indicator of technical teleworkability (derived from the physicality of occupations) with the simple indicator of use of computers at work that we extracted from the 2015 EWCS, as previously explained. This is shown in Figure 19. The representation is very similar as the one previously used for comparing technical teleworkability and social interaction by occupation, with the figure horizontally split in three panels (non-teleworkable occupations in the left, partially teleworkable in the middle and fully teleworkable in the right). In this case, the vertical axis represents the intensity of use of computers in each occupation.

The association between the two variables (technical teleworkability and computer use) is very strong and positive: more technical teleworkability is generally associated with more computer use. As we already hinted in the section presenting our conceptual framework, this was to be expected since computer use is a good proxy of information processing tasks (since most information processing is carried out with computers nowadays), and thus it can be considered as a good proxy of teleworkability measured in a positive rather than a negative way.

In other words, the strong positive association between our index of teleworkability (which was constructed purely on the basis of data on physical interaction tasks, in a reverse scale) and the simple indicator of computer use is a very positive outcome because it externally validates our approach (since both measures are completely independent yet they correlate as they should). Of course, the correlation is not perfect (the coefficient of determination R^2 is 0.68), and it is interesting to inspect where they diverge.

Jobs with low teleworkability but high computer use include telecommunications and broadcasting technicians, medical and pharmaceutical technicians, engineering professionals, life science professionals and architects: these are highly skilled technical occupations that make very intensive use of computers yet have a significant physical component (in terms of inspecting materials, operating with equipment, manipulating stuff), and thus are not teleworkable according to our approach. In this sense, our assessment seems more adequate than the one that would derive from

just looking at computer use to assess teleworkability: these jobs are not highly teleworkable despite making very intense use of computers.

On the other diagonal we can see some jobs with high teleworkability in our index but low computer use, including primary school teachers and other teaching professionals. Again, the values of our index provide a more sensible assessment of the teleworkability of these outliers than the simple computer use proxy: these are indeed teleworkable occupations despite making relatively limited computer use (as attested by the fact that most teachers shifted to a telework regime in most European countries during the confinement period; see Fana et al 2020).

In short, the comparison of our technical teleworkability index with a simple indicator of computer use by occupations provides some confirmation of the validity of our approach.

Figure 18: Technical teleworkability vs. social interaction indices (Source: ICP and EWCS, own elaboration)

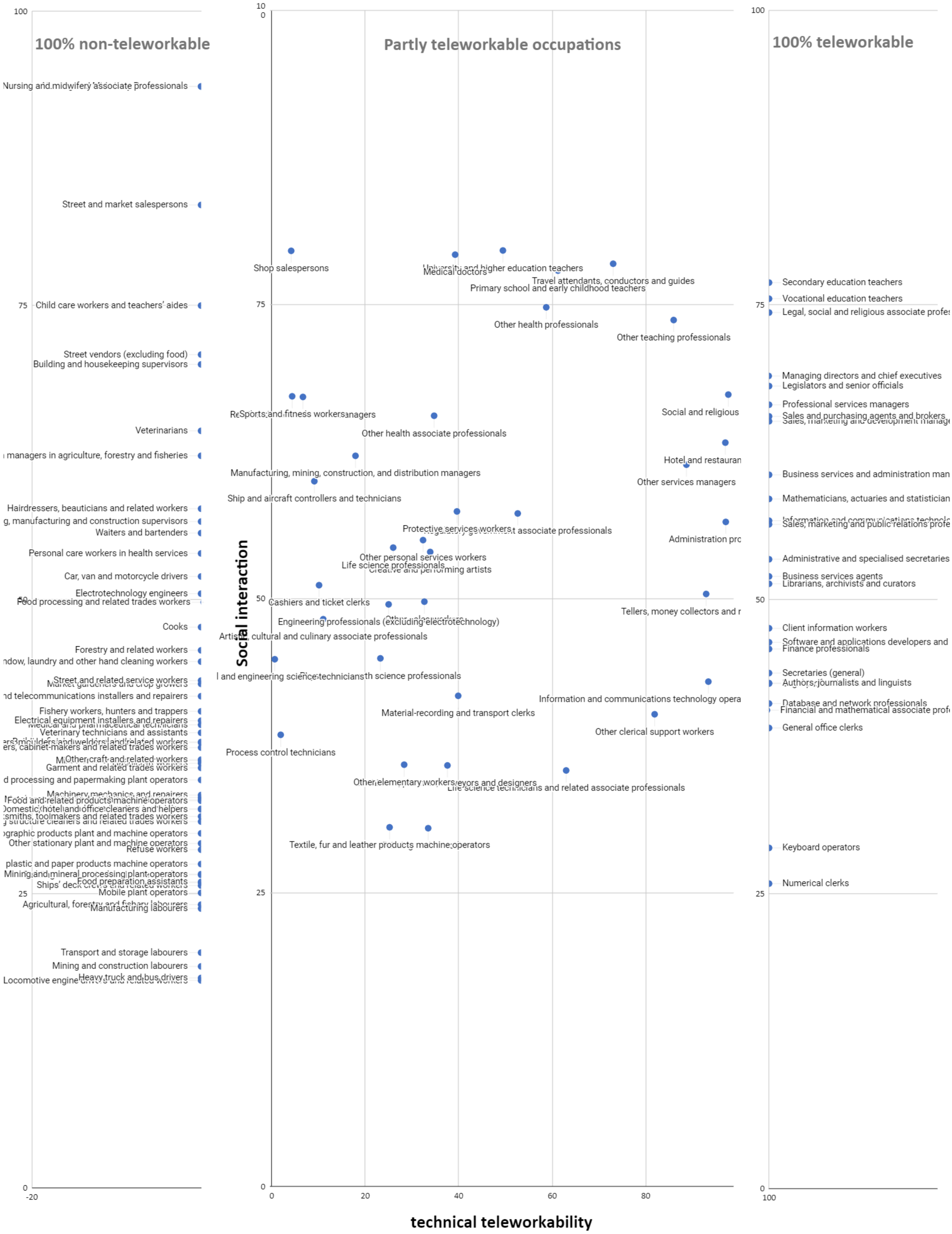
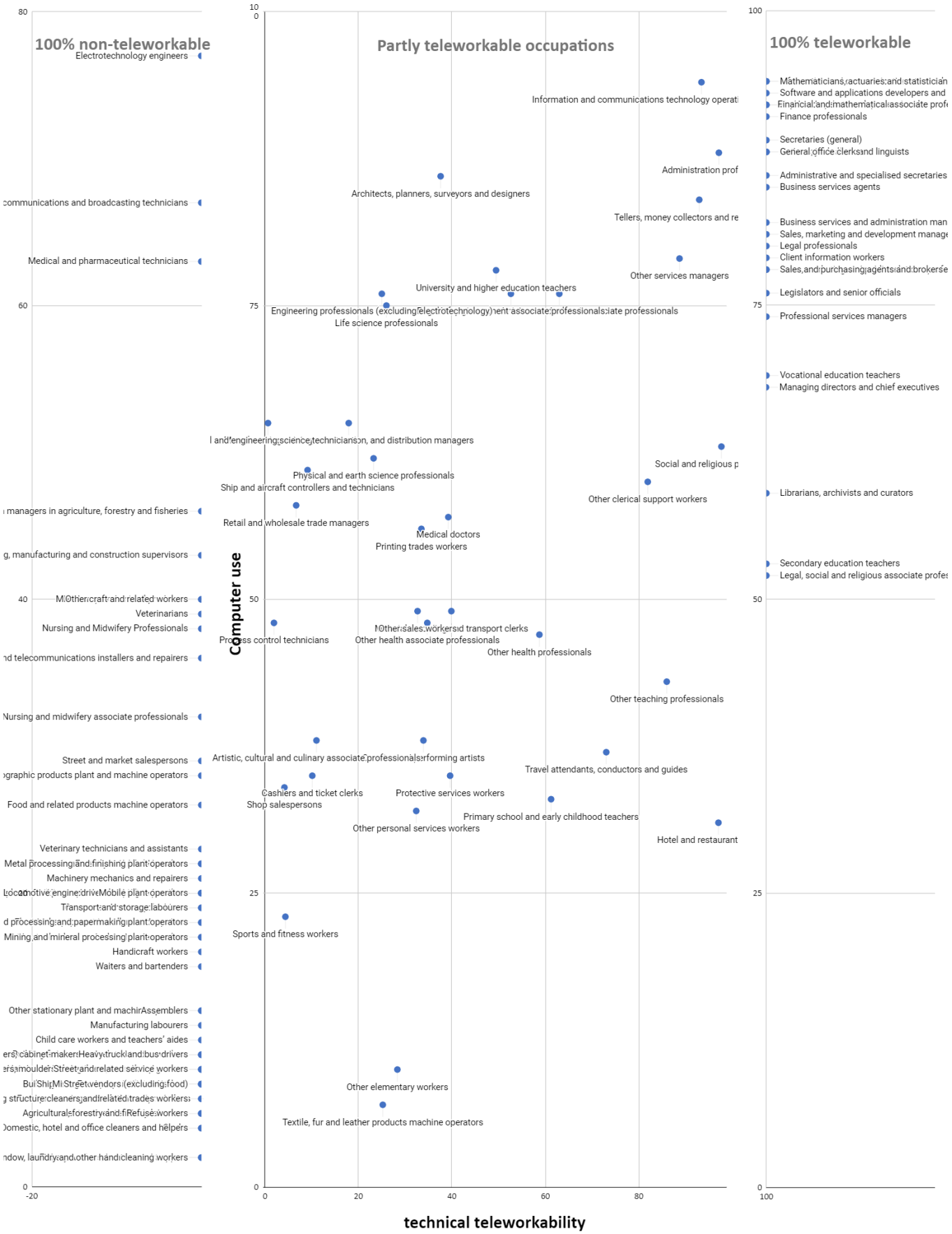

100% non-teleworkable
Partly teleworkable occupations
100% teleworkable
Social interaction
technical teleworkability
Nursing and midwifery associate professionals
Street and market salespersons
Child care workers and teachers' aides
Street vendors (excluding food)
Building and housekeeping supervisors
Veterinarians
Hairdressers, beauticians and related workers
Waiters and bartenders
Personal care workers in health services
Car, van and motorcycle drivers
Electrotechnology engineers
Food processing and related trades workers
Cooks
Forestry and related workers
Street and related service workers
Fishery workers, hunters and trappers
Electrical equipment installers and repairers
Veterinary technicians and assistants
Garment and related trades workers
Machinery mechanics and repairers
Food and related products machine operators
Other stationary plant and machine operators
Refuse workers
Food preparation assistants
Mobile plant operators
Manufacturing labourers
Transport and storage labourers
Mining and construction labourers
Heavy truck and bus drivers
Shop salespersons
Medical doctors
Travel attendants, conductors and guides
Primary school and early childhood teachers
Other health professionals
Other teaching professionals
Sports and fitness workers
Other health associate professionals
Social and religious
Manufacturing, mining, construction, and distribution managers
Other services managers
Ship and aircraft controllers and technicians
Protective services workers
Administration pro
Other personal services workers
Life science professionals
Cashiers and ticket clerks
Tellers, money collectors and r
Engineering professionals (excluding electrotechnology)
Artistic, cultural and culinary associate professionals
Information and communications technology opera
Material-recording and transport clerks
Other clerical support workers
Process control technicians
Textile, fur and leather products machine operators
Secondary education teachers
Vocational education teachers
Managing directors and chief executives
Legislators and senior officials
Professional services managers
Sales and purchasing agents and brokers
Mathematicians, actuaries and statistician
Administrative and specialised secretaries
Business services agents
Librarians, archivists and curators
Client information workers
Finance professionals
Secretaries (general)
Authors, journalists and linguists
Database and network professionals
General office clerks
Keyboard operators
Numerical clerks
100
75
50
25
0
-20
20
40
60
80

Figure 19: Technical teleworkability vs. computer use at work (Source: ICP and EWCS, own elaboration)



Finally, we can also compare our assessment of teleworkability as technical feasibility and the pre-outbreak patterns of telework by occupations. It is important to note that, as discussed in the previous section, we would expect these to differ in significant and specific ways. Whereas during the COVID-19 crisis we can more or less assume that anyone who could telework did move to a telework regime, and thus teleworkability as a technical feasibility became the main criterion for telework as a practice, before the COVID-19 crisis not everyone who could telework did so. Indeed, pre-outbreak evidence suggests that telework tended to be more frequent in upper occupational levels because of reasons other than technical feasibility, possibly related to work organisation (managers and professionals enjoy more autonomy and less monitoring of their work) as well as hierarchical power.

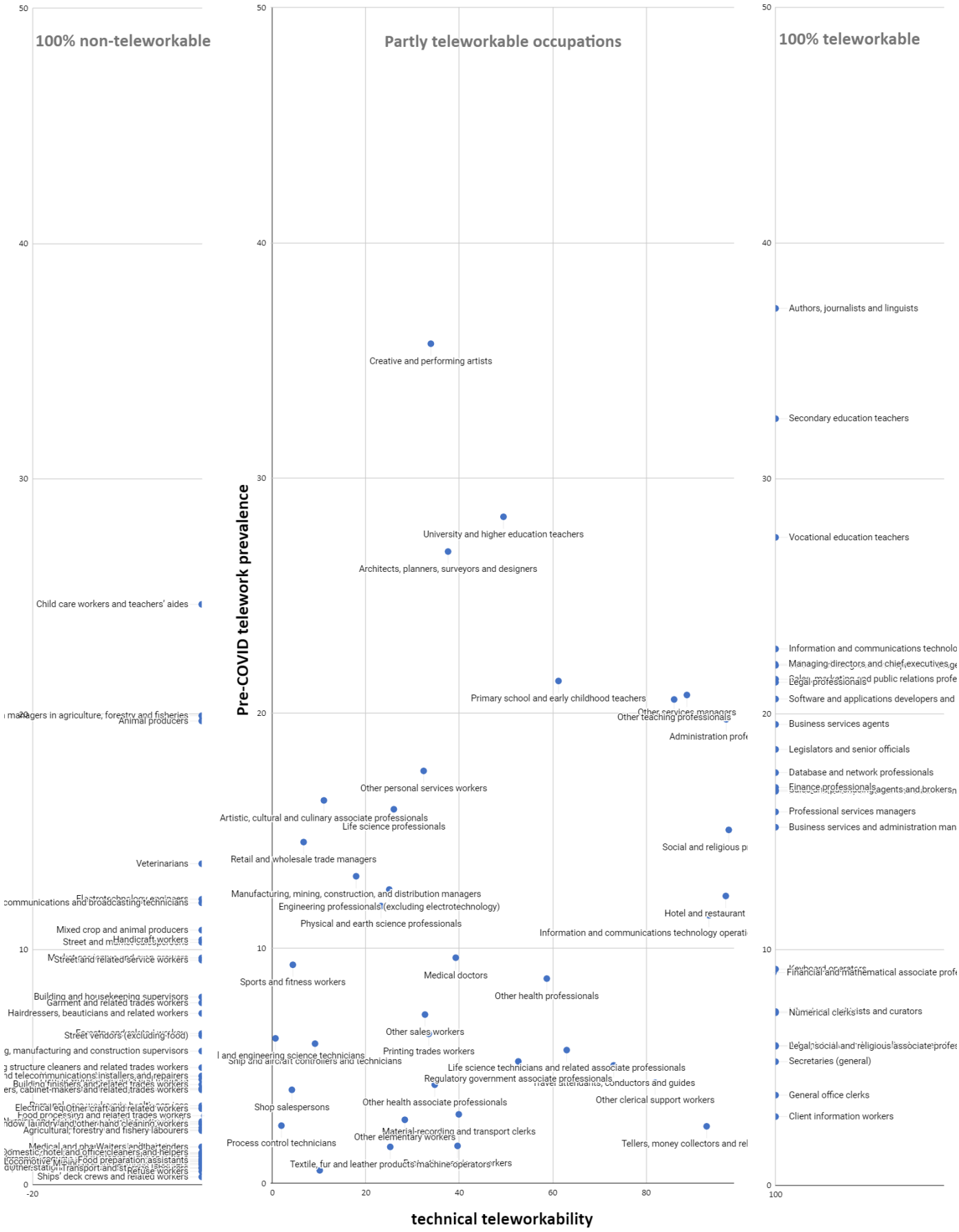
Figure 20 allows to compare technical teleworkability potential, as measured in this paper, with pre-outbreak telework across occupations using data from 2018 LFS survey, reflecting the average prevalence of telework in the EU27 as a whole. The setup of the figure is similar to the two previous ones, with technical teleworkability in the horizontal axis (split in three panels), and in this case the pre-outbreak prevalence of telework in the vertical axis. It is important to note that the scale of the vertical axis has been changed to 0-50 (rather than 0-100 as in the two previous charts), because the prevalence of telework before the COVID-19 crisis did not reach a value above 40 in any occupation.

We can observe that, as in the previous cases, there is some positive association between the two variables displayed. However, the association is much weaker than between teleworkability and computer use, with a coefficient of determination of 0.29. At the left-hand panel we can see that the vast majority of occupations that are classified as non-teleworkable (or almost non-teleworkable) in our approach had an extremely low prevalence of telework before the COVID-19 crisis. There are some exceptions which are worth inspecting in detail: childcare workers, managers in agriculture and animal producers had relatively high prevalence of telework before the outbreak. In the case of agricultural professions, this probably reflects a different type of homeworking (not so much providing labour remotely but working in farms which are also the private home of the workers); in the case of childcare workers it can relate to class preparation (which is frequent in many teaching professions) or to the provision of childcare from home.

On the other side of the horizontal axis of technical teleworkability, the correlation between the two indices is clearly much weaker. In fact, for occupation groups with very high or full teleworkability in our approach, the capacity of our index to (retrospectively) predict the values of pre-outbreak telework is poor. There are occupations with high pre-outbreak telework prevalence (authors, artists, teachers, architects, ICT professionals) but widely varying teleworkability indices. And on the other hand, there are many occupations that we classified as highly teleworkable (mostly, clerical workers and administrative assistants) which before the COVID-19 crisis had very low rates of telework. Most managers and professionals, on the other hand, receive very high levels of teleworkability in our index and also had relatively high scores (around 20) in pre-outbreak telework prevalence.

These results are consistent with our conjecture that pre-outbreak telework was not only a matter of technical feasibility, but also about work organisation, hierarchical power, regulation, and preferences. Occupations classified as technically not teleworkable tended to have extremely low values of telework before COVID, but occupations classified as highly teleworkable had high or low values of telework before the COVID-19 crisis depending mostly on their organisational and hierarchical position.

Figure 20: Technical teleworkability vs. pre-COVID telework prevalence (Source: ICP and EU LFS, own elaboration)



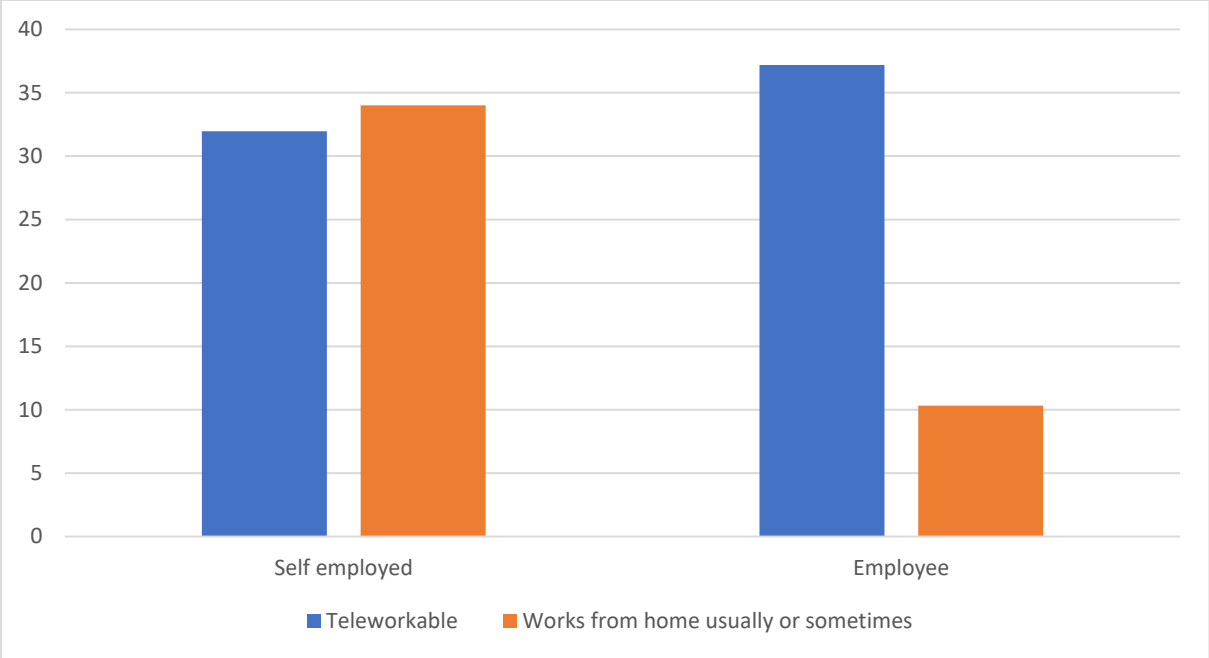
Teleworkability across the EU

With the occupational teleworkability indicator developed in the previous pages, we can now look at what this means in terms of employment share by member state and for different categories of workers.

The question we are trying to answer is what share of current dependent employment is working in occupations that can technically be carried out at home, meaning that there are no specific physical requirements of the job that would prevent it. We derive these estimates by simply multiplying the technical teleworkability scores of ISCO 3-digit occupation groups, derived in the previous section, by their employment levels across the EU as measured by the 2018 Labour Force Survey. For those 3-digit ISCO occupations groups that are only partially teleworkable – those with a technical teleworkability score between 0 and 1 – this projection implies that only a corresponding share of those employed in the group are considered teleworkable.

The first observation from these estimates is that the share of employment that is potentially teleworkable (around 37%) is much greater than the actual prevalence of teleworking pre-outbreak (15%) among all EU27 workers. This gap is equivalent to over one in five workers (22%, or 43 million workers) in the EU27 who could be working from home but did not do so before the COVID-19 crisis. The second main observation is that nearly all this gap is comes from the ranks of dependent employees (see Figure 21).

Figure 21: Share of teleworkable employment compared to incidence of teleworking (2018), EU27



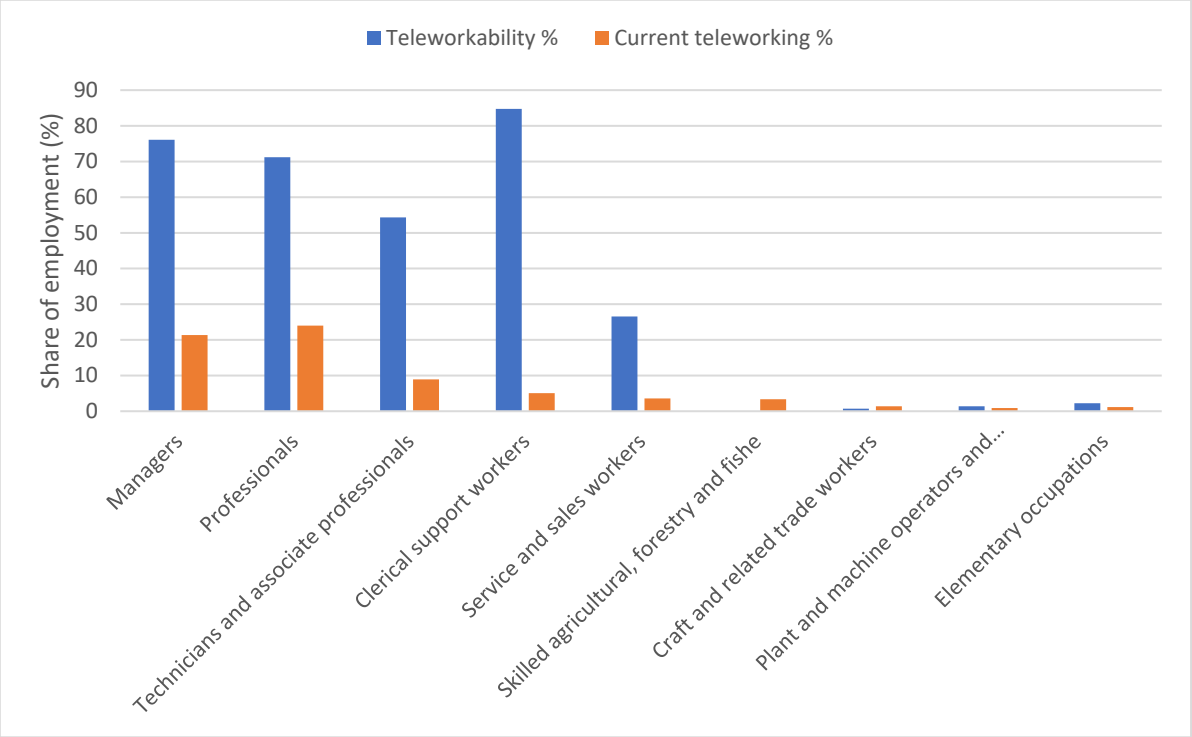
Source: LFS. Note: 'teleworkable' refers to share of employment in teleworkable occupations according to our operationalisation; 'works from home usually or sometimes' refers to share of employment from LFS 2018 microdata (EU27)

For the self-employed – who in principle have much greater discretion over how and where their work is carried out – there is a much closer correspondence between actual teleworking and technical teleworkability. Indeed, a somewhat higher share of the self-employed reported working from home based on LFS 2018 (34%) compared to their share of employment in teleworkable

occupations (32%).[16] A higher share of dependent employees than of the self-employed is working in technically teleworkable occupations, so if we assume that during the COVID-19 crisis everyone who can telework is teleworking, this would imply a reversal of the actual pre-outbreak prevalence.

Henceforward, we focus on the category of dependent employees, which accounts for over 5 in 6 workers across the EU27, and where the gap between potential and actual teleworking is greatest. A first striking difference in teleworkability relates to the white-collar / blue-collar occupational divide (see Figure 22). White-collar work is much more teleworkable than blue-collar work, where the physical requirements of the jobs and associated place-dependence render most occupational categories non-teleworkable.

Figure 22: Teleworkability and actual teleworking among employees by broad occupation group



Source: LFS, COVID group. Note: employees only. "Teleworkability" refers to share of employment in teleworkable occupations according to our operationalisation; 'Current telework' refers to share of employment working from home usually or sometime according to LFS 2018 microdata (EU27).

This differential was also observed for teleworkable employment in Italy in separate analysis (Cetrulo et al, 2020). In the ISCO occupational groups 7-9 (craft and related trades workers, plant and machine operators and elementary occupations), the share of teleworkable employment is less than 2%; and actual incidence of teleworking is 1% or less. By contrast, in ISCO groups 1-4, a large majority of employment is technically teleworkable (from 54% of associate professional employment to 85% of clerical support workers).

While this correlates to a higher incidence of actual teleworking in these occupations compared to the blue-collar occupations, the gap remains large between actual and potential teleworking. While

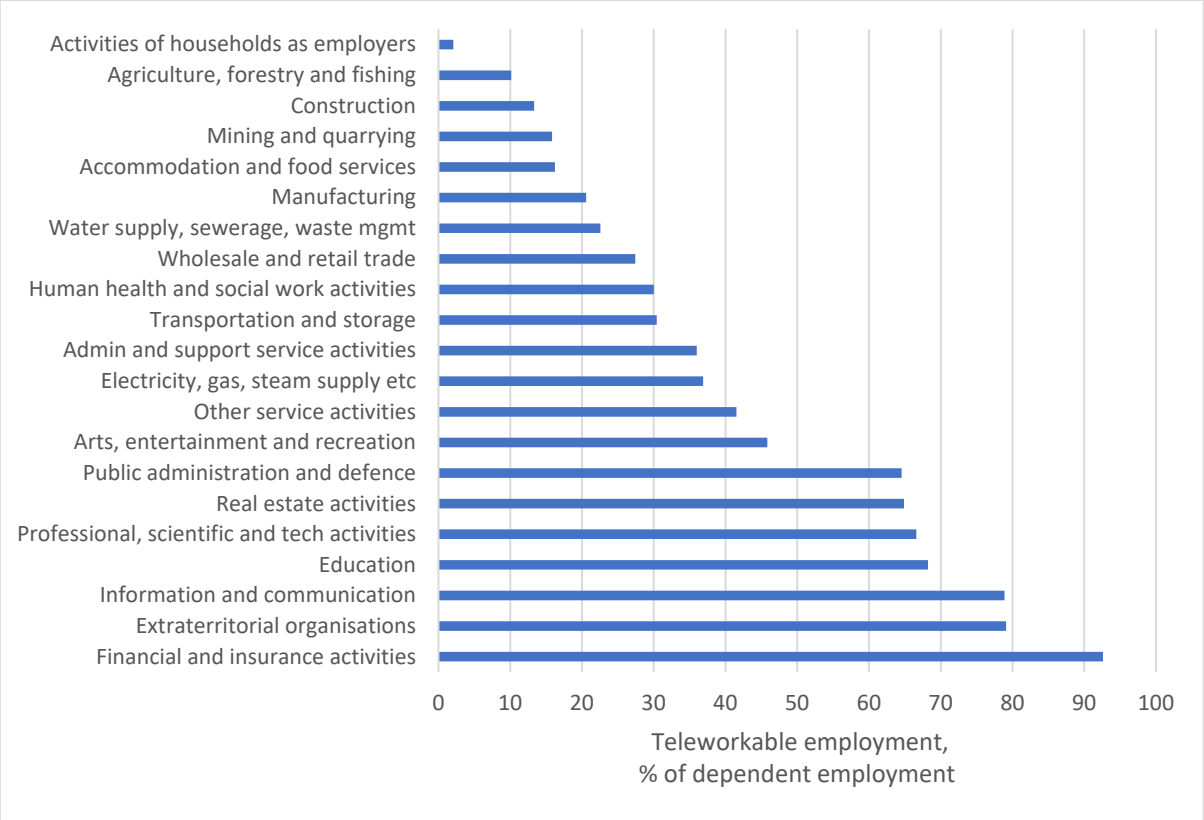
[16] Due in part to our permissive operationalisation of actual homeworking as those who indicate either working from home 'usually' or 'sometimes', which may lead to over-estimation.

71% of professionals could work from home, around a quarter (24%) actually did so. The gap is even wider in the case of lower-level white collar occupations (clerical support workers) where the characteristics of the job are such that almost all could be teleworked (84%) while actual teleworking incidence remains very marginal (5%). This supports our hypothesis that access to teleworking has hitherto been conditioned by position in the occupational hierarchy and associated privileges, more than by the task composition of the job.

The evidence in this report suggests that during the COVID-19 crisis the large expansion of telework has followed the occupational distribution indicated below – a strong skew towards white-collar employment where much work has shifted from office to home, while workplace closures have resulted in furloughing (or job loss) for blue-collar occupations where there is little realistic option of teleworking. Over and above this, it is likely that access to telework has become more evenly distributed within white collar occupations on the assumption that enforced closures have resulted in many new teleworkers amongst low and mid-level clerical and administrative workers who previously had limited access.

The teleworkable employment shares are predictably higher among service sectors with high shares of white-collar employees (see Figure 23).

Figure 23: Teleworkability in EU27 by sector

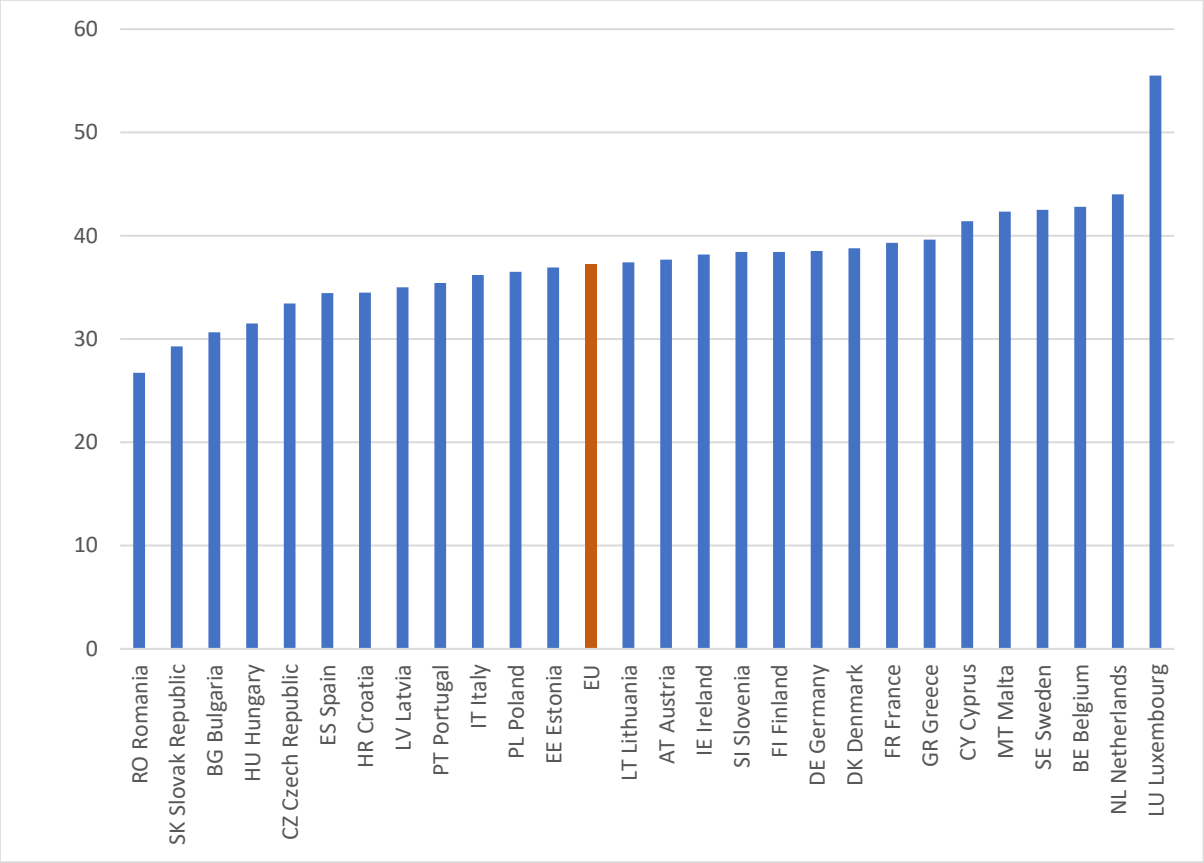


Source: LFS, COVID group. Note: employees only

Nearly all financial-services employment is teleworkable (93%) as well as nearly four in five employees in information / communication (79%) and around two-thirds of employees in real estate, professional, scientific and technical activities, education and public administration. Service sectors with lower shares of teleworkable employment include health (30%), retail (27%) and accommodation/food services (16%). The primary sector, manufacturing and construction sector all have low shares of teleworkable employment (10-20%).

Because we measure teleworkability as an attribute of occupations, constant for the same occupations across different countries, the share of teleworkable employment varies by member states based only on the composition of their workforce (see Figure 24).

Figure 24: Share of teleworkable employment, by country, in EU27



Source: LFS, COVID group. Note: employees only

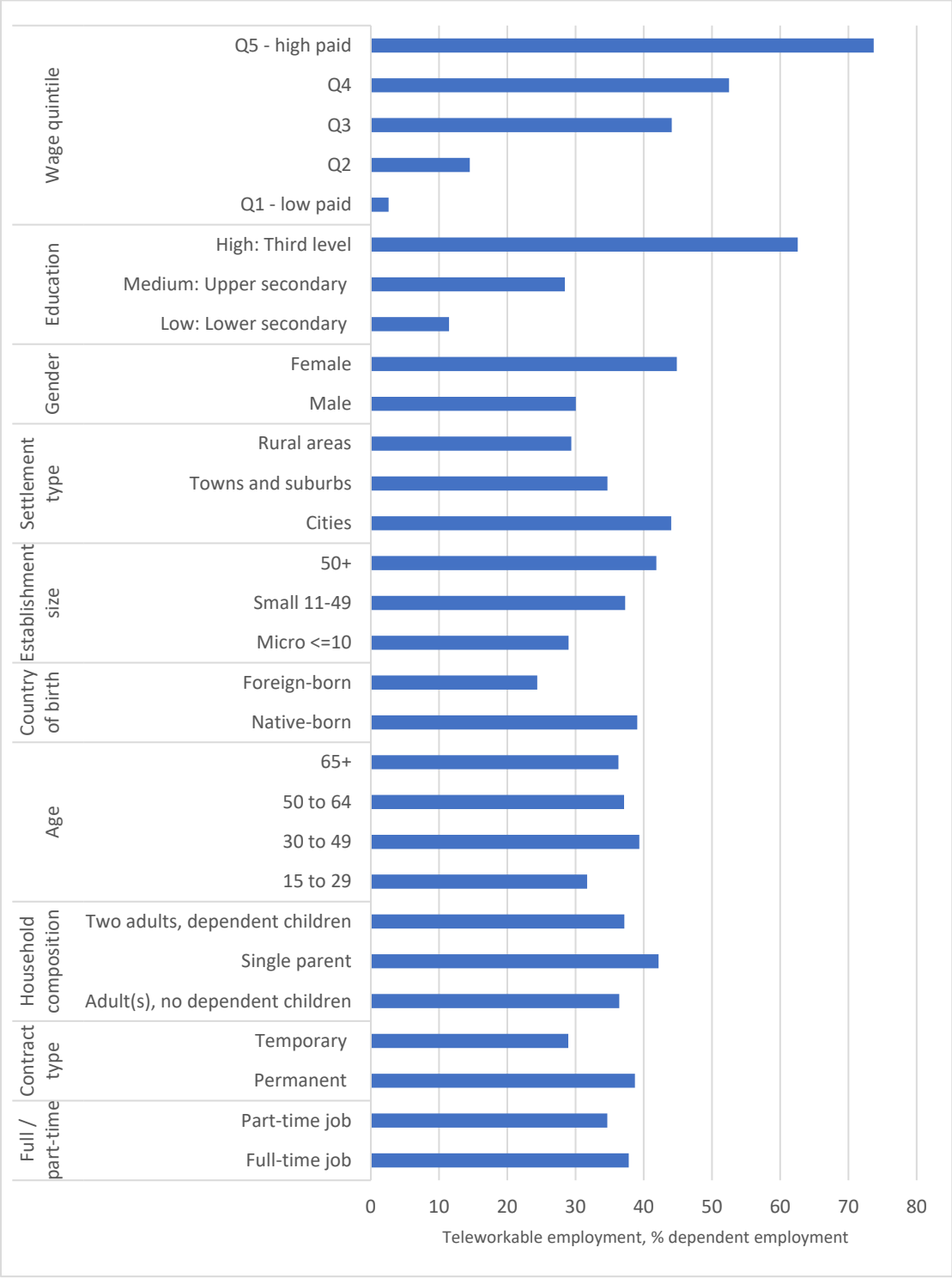
This means that countries with higher shares of white-collar occupations – and the sectors where these are more prevalent – have a larger share of employment that is teleworkable. The estimates thus cannot take into account differences between member states in ICT technology, regulation, and size of companies.

According to our estimation, the range of teleworkable employment is from 27% in Romania to just over twice that in Luxembourg (54%). The highest share of teleworkable employment tends to be in the Nordic and Benelux countries, and correlates largely with the ranking of countries by pre-outbreak teleworking prevalence. The lowest shares are in Eastern Europe and also in some of the larger member states in Southern Europe (eg., Italy and Spain) where, as we have already seen, other sources point to relatively low teleworking incidence.

Overall, there is relatively limited variation between countries: in all member states except five, the share of teleworkable employment ranges between 33 and 44% of total employment.

Finally, Figure 25 (next page) summarises differences in the teleworkable share of employment by various personal, job-related or spatial characteristics.

Figure 25: Share of employees in teleworkable occupations



Source: LFS, COVID group, Structure of Earnings Survey. Note: employees only. Job-wage quintiles based on author's calculations of SES 2014 data.

The most obvious determinants of whether an occupation is teleworkable or not is the wage and education level of the average job-holder. Three-quarters (74%) of those in jobs in the highest-paying quintile can telework. The teleworkable shares of employment are well above average also in mid-paid and mid-high paid jobs (Q3-Q4) before falling off sharply at the bottom of the job-

wage distribution. Only 3% of those in the lowest quintile are in teleworkable employment. Given the strong correlation between job-wage and job-qualifications, it is not surprising to see this sharp wage gradient of teleworkability reflected in the differentiation by educational qualification. Around two-thirds (64%) of third-level graduates work in teleworkable occupations, but a much smaller share of those with lower levels of qualification.

Box 6: teleworkability, social interaction and computer use

In our approach, the sole determinant of occupational teleworkability in is the lack of physical handling tasks. As indicated earlier, the quality of teleworkability will depend also on the extent to which an occupation requires extensive social interaction. Where an occupation is rich in social interaction tasks, telework will inevitably involve some loss of quality given the limitations of existing ICT technologies. Where an occupation is teleworkable and involves only limited social interaction, it should in principle be capable of being carried out with no or limited loss of quality. Prospectively, it is in these latter occupations where, if there is a general increase in teleworking post-COVID, it could be expected to occur earliest and fastest. Conversely, in occupations such as those of secondary school teachers, the expectation would be that post-COVID, most work while technically teleworkable would revert to its traditional locus in schools and classrooms.

Table 3: three categories of teleworkability, characteristics, EU27*

Occupation Type	Employment share %	Computer use	Social interaction	Pre-COVID telework	Physical teleworkability	Occupation (n, ISCO3d)	Example
Not teleworkable	66	27	47	5	7	83	Doctors
Telework, limited social interaction	13	86	41	11	97	14	Finance professionals
Telework, extensive social interaction	22	67	65	17	90	26	Secondary School teachers

Source: LFS, EWCS, ICP.

Teleworkable occupations account for 37% of dependent employment, but the majority of teleworkable jobs are those with extensive social interaction where teleworking may not be optimal. This was also the case in terms of pre-COVID telework incidence. Only 13% of employment is in occupations that are teleworkable and involve limited social interaction. In these occupations (eg., finance professionals) computer use is more intensive than in teleworkable jobs with extensive social interaction (eg., secondary school teachers) and much more intensive than in non-teleworkable occupations. In other words, beyond the main physical teleworkability criterion, computer use intensity is a strong additional or complementary indicator of teleworkability.

Note *: three occupational categories generated as follows. A cut-off point of 40 on the physical teleworkability scale to differentiate between teleworkable and non-teleworkable occupations (ISCO 3d) – as in the construction of the original index itself. For this reason, the shares of employment diverge marginally from those already presented in this section and the physical teleworkability share is positive and non-zero (7%) in the 'not teleworkable' category. We then further differentiate teleworkable jobs based on the social interaction scale discussed in the previous section and use a cut-off to differentiate between occupations with limited (<50) or extensive (>=50) social interaction. Computer use intensity = occupational mean scores based on 6EWCS. Pre-COVID telework based on LFS 2018 'homework' question scaled as follows – sometimes=0.4, usually=1, never=0. ISCO categories excluded: armed forces, subsistence farmers.

Another striking finding from Figure 24 (page 48) is that a much higher share of women than men (45% compared to 30%) are in teleworkable occupations. As we have seen, the incidence of teleworking has been similar by gender in pre-outbreak representative surveys, though the Eurofound COVID-19 survey data did show a small differential (41% of female employees and 37% of male report starting to telework since the onset of the current crisis). The gender difference in teleworkability relates in part to patterns of sectoral segregation with men in particular over-represented in sectors with limited teleworkability potential such as agriculture, mining, manufacturing, utilities and construction. Even in these male-dominated sectors, the female teleworkable share of employment tends to be high. In construction, only 6% of male employment is teleworkable compared to 69% of female employment with similar differentials observed in utilities, mining and transportation and storage. This reflects the fact that female workers tend to work in different jobs than men in these sectors and that these jobs tend to be the teleworkable ones – office-based, secretarial or administrative in nature, with a lower share of physical handling tasks. In addition, within the main occupational groups, the female teleworkable share of employment tends to be higher; 86% of female managers and 89% of female clerical support workers are in teleworkable jobs compared to 75% and 73% respectively of their male counterparts.

Teleworkable employment tends to be more common among native-born workers than foreign-born, among those on permanent contracts compared to those in temporary contracts and among those in larger establishments than smaller establishments. [17] The spatial distribution of employment is also a discriminating factor as cities, with their higher share of services employment – in particular of the knowledge-worker or symbolic analyst type of occupation – have more teleworkable employment (44%) than towns or suburbs (35%), or rural areas (29%).

Other characteristics, such as age, full-time / part-time status and the household composition of job-holders, do not appear to differ significantly between teleworkable and non-teleworkable occupations.

Overall, based on employment shares from the EU Labour Force Survey and our detailed technical teleworkability index, we find that the distribution of teleworkable employment is consistent along a number of dimensions with the evidence from both pre- and post-outbreak surveys. There is a large gap between the share of dependent employees who could perform their work remotely and the share that regularly or occasionally did so pre-crisis. We estimate that this gap amounts to over 20% of total EU27 employment or over 40 million workers. This would put our estimate of teleworkable employment (36%) – or 37% of dependent employment – close to the middle of the range of estimates from real-time surveys conducted during the COVID-crisis. The incidence of actual teleworking and technical teleworkability have therefore converged closely because of the crisis.

Teleworking is feasible almost exclusively for those in white-collar occupations and largely non-feasible for those in blue-collar occupations. This skew towards higher-level occupations is starkly evident in a steep gradient of teleworkability by completed educational level and, especially, job-wage quintile with three-quarters of the highest-earning 20% of workers able to work from home but less than one in twenty of the lowest-earning 20%. The striking result related to the gender of teleworkable occupations with females 50% more likely than men to be employed in such occupations – though access to teleworking post-crisis is likely to be inflected by issues of organisational position and power, as was the case pre-crisis, which could tend to narrow or eliminate this gap.

[17] Though the EU-LFS categorisation is limited in capturing larger establishments as the largest category is establishments with 50 or more employees.

Discussion

Teleworkability and work organisation

In this paper, we have defined teleworkability in terms of technical feasibility, which we have argued depends essentially on the technologies available for remote communication and their interaction with the different types of task content (physical, intellectual or social). But the tasks framework that we use in this paper includes as a crucial dimension also work organisation, which refers to how work is socially coordinated. Although we do not focus on this aspect, there are a few considerations that are still useful to make. We will again follow the structure of the framework proposed by Fernández-Macías and Bisello (2020), and thus discuss three main aspects of work organisation: autonomy (and control), teamwork and routinisation.

As we have already mentioned, the problem of autonomy and control in the case of telework is probably the main reason why in the last few years it has not become more frequent despite the growing – though not yet universal – availability of ICT. Depending on the implementation, telework can imply a very significant level of autonomy for the worker: when work is carried out from the private home of the worker, the traditional office-based mechanisms to monitor working time and quality of work may not be available, especially for those jobs where output quality and quantity is intrinsically more difficult to measure. In other words, whereas the physical presence of the worker in the employers´ premises facilitates the monitoring and control of those aspects of work (methods, hours, effort), in the case of telework the monitoring of work is much more difficult, and thus requires a much higher level of trust. That is probably why workers in a supervisory capacity (managers) or whose work effort is intrinsically difficult to monitor anyway (professionals) were the most frequently allowed to telework before the COVID-19 crisis. Or to put it the other way round: this is one of the reasons why many mid-skilled workers whose tasks were easily teleworkable with current ICT tools – for instance, clerical workers who mostly perform information-processing tasks – teleworked only very rarely before the COVID-19 crisis, as shown in the previous sections. There may also be cultural norms at play: for instance, work done remotely may be perceived as less visible or recognised within the organisation, which may deter some employees from teleworking, if they fear that doing so would undermine their chance for professional advancement.

Clearly, this situation drastically changed with the COVID-19 crisis. Given the public health risks associated with commuting and work presence in this context, all of a sudden teleworkability as a technical feasibility became the sole factor determining who could work from home. Essentially, everyone that could telework had to telework. As entire organisations moved to telework at the same time, under difficult circumstances, even of those who already had some experience of telework may have experienced changes in their routines and work organisation practices. The change was even more radical for the many mid- and low-skilled workers who could very rarely telework before. Organisations may feel the need to adapt to this arrangement, and may try to introduce increasingly intrusive forms of remote control and surveillance of the work carried out from home. Some recent anecdotal or journalistic evidence on the increasing use of technologies of remote surveillance for employees (for instance, with algorithmic control of the physical presence of the employee in front of the computer as recorded by the camera) points in this direction.[18]

[18] There is no scientific evidence yet on this because it is simply too early, but journalists have been reporting on increasing levels of monitoring work at home from the beginning of the pandemic, see for instance: “Working from home surveillance software for your boss” (Washington Post, April 11 2020), “How My Boss Monitors Me While I Work From Home” (New York Times, May 6 2020), “Employee monitoring software surges as companies send staff home” (ABC News, May 21 2020).

The second aspect of work organisation that is relevant for telework is teamwork and in general social interaction with colleagues. In this respect, we can apply by analogy many of the considerations previously made about social interaction task content: to the extent that a given occupation or job necessarily requires a lot of teamwork or social interaction with colleagues, telework can negatively affect the quality of the labour input provided. We would argue that, since telephone, videoconference and other online collaboration tools are easily available and increasingly of good quality, the need to socially interact with colleagues cannot be considered as a hard barrier to telework, but as something that can make it more or less difficult for different occupations. However, work organisation has more *plasticity* than task content (which is directly determined by the material properties of the transformation process in each job) and can be more easily adapted to changing conditions if necessary.

The third aspect of work organisation to be considered is the level of routine/standardisation of tasks. The routinisation and standardisation of tasks can be used as a form of coordinating work by procedures rather than by direct human intervention, and thus can also facilitate the remote provision of work (by reducing the need of direct coordination of work). In fact, Pouliakas and Branka (2020) show that the task profile of EU remote workers is mostly characterised by standardised tasks. That largely reflects the fact that tasks standardisation, especially when combined with algorithmic control and digital monitoring devices, can actually enable a high degree of control of work processes even when they take place remotely. This is probably one of the key sources of success of digital labour platforms such as Uber or ClickWorker: they are very efficient at coordinating the remote provision of labour at large volumes, solving the autonomy and control problem by standardising tasks, monitoring effort and managing algorithmically.

Therefore, although these three aspects of work organisation are not determinants of teleworkability understood as a technical feasibility, they can nevertheless facilitate it or impede it. Therefore, a fuller understanding of the determinants of telework would go beyond technical feasibility and social interaction, and also capture the organisational difficulty of telework in specific occupations, measuring the degree of autonomy (which correlates positively with telework), teamwork (less teamwork, easier to organise telework) and routineness (more routine tasks, easier to organise telework). All these factors would require additional surveys and data to be implemented consistently across the European Union.

Some considerations on telework after the lockdown

The massive expansion of telework during the COVID-19 pandemic can be considered a large-scale natural experiment in work organisation; an improvised and ad-hoc response at the level of states and organisations to a rare circumstance – a global pandemic, and state restrictions on mobility and physical distancing designed to contain it. Instead of being compelled to work at their employer's premises, many employees were, for a limited period, compelled to work from home. As our societies gradually return to normality, many employees will resume their routine commute to and from work and the incidence of "full-time" teleworking will once again decline.

There are however many reasons to believe that there will be a lasting legacy from the current episode where a quarter or more of employees have been working remotely from home. Some employers are considering changes to their working arrangements, extending the possibility to telework, and may even rethink office-based work altogether. Policymakers have the opportunity to reflect on what the current experience of teleworking means about the nature of work and its future.

At least for the next few months, as confinement measures are relaxed, some physical distancing measures are likely to remain in place – limiting the possibilities for a full return to work for many. Rotating telework will be one option with staff rostered to work some days at work, some days at home. Possible fresh outbreaks mean that any resumption of workplace activity is likely to be

tentative and conditional in an initial period lasting many months. For this reason, in the short-term there will continue to be extensive recourse to telework.

In a longer-term perspective, after the COVID-19 crisis is resolved by the discovery of vaccinations or other medical remedies, there is likely to be greater acceptance and encouragement of teleworking possibilities based on the knowledge that organisations, HR personnel and managers as well as individual workers have gained from the period of enforced telework. There are also other factors likely to increase the incidence of teleworking in the long term. Some are structural, some employer-motivated, some employee-motivated.

On the structural side, compositional changes in employment – notably if the current shift to services, increases in educational attainment and skills, and overall occupational upgrading continue – mean that a higher share of employees will be doing work that is amenable to teleworking. As this paper has demonstrated, such work is heavily skewed to higher-level white-collar occupations. At the same time, the continual upgrading of IT infrastructure, including high-speed broadband availability and enhanced online collaboration tools – in videoconferencing and team collaboration for example – will enable virtual work connections for more employees regardless of location and reduce the 'quality gap' between remote and in situ work.

Employers may have diverse reasons for wanting to broaden access to telework. Some of the leading technology firms have already indicated an openness to or encouragement of much more extensive teleworking in the near future. If trends in Silicon Valley are any guide, Facebook chief executive, Mark Zuckerberg, has predicted that half of the company's employees may work permanently from home by 2020 (Sandler, 2020). His counterpart at Twitter has said that post-outbreak all staff wishing to continue working remotely would be allowed to do so 'forever' and granted extra company money to fund the necessary physical equipment. In part, this responds to a perceived demand both among current and potential recruits; organisations that do not offer this possibility may in the future be considered less attractive places to work, a trend that was already apparent in recent years (Mandl et al., 2015).

The period following COVID-19 outbreak has provided employers with an unplanned organisational learning opportunity in telework provision from the perspective of human resources, work organisation, productivity and ICT infrastructure and software. Some employers will have learnt that broader access to teleworking was technically achievable with limited negative impacts on performance. This learning-by-doing is likely to have persuaded previously sceptical managers and employers that a broader application of teleworking, beyond the happy few, is both feasible and desirable. The lessons learnt will facilitate contingency planning of organisations in a broader sense; work that is place-independent is intrinsically more resilient.

Employers are likely also to be motivated by cost considerations, for example in relation to building and office rental and maintenance. The prospect of greater shares of employees working remotely (at least part of the time) may lessen the reliance on rented space. For cash-strapped businesses post-outbreak, this is likely to be an important consideration. In tandem, more remote working may also encourage a related cost saving in reduced work travel as some events, meetings and staff training sessions move online. An important caveat is that employee preferences indicated in surveys are for occasional telework – i.e., a mix of workplace presence and working from home on alternate days. Real estate cost savings for employers would be harder to achieve in this scenario without extensive 'hotdesking' which itself may entail additional management and administration overhead. Employers will also need to confront new challenges posed by a change in working arrangements, such as dealing with employee's work-related health and safety outside the office, monitoring performance and working time, and effectively coordinating workforce remotely. There may also be a need to compensate for the expenses incurred by employees to set up workstations and internet connections, and associated energy expenses. Many of these issues call for discussion between social partners and may require new legislation.

The geography of employment may also change. As we have seen, the types of occupations that lend themselves to teleworking are over-represented by employment share in large metropolitan areas. It is these more densely populated zones that have traditionally suffered more congestion, resulting in longer commuting times – and inspired the concept of telework in the first place (Nilles 1976). Densely populated areas tended to suffer more negative health outcomes from the COVID-19 outbreak; they are also the places where telework has been especially important in protecting public health. These are also zones where rental and living costs are highest, and where employers pay higher salaries as a result (Moretti, 2012). On a national scale, this raises the possibility of location-adjusted wages for teleworkers; employees willing to work from home in a lower cost zone could be paid less than their counterparts commuting in higher-cost areas, which may fall foul of the principle of equal pay for equal work. The long-term demand for housing, office space, and food and hospitality services in metropolitan areas may also shift towards smaller urban and rural areas.

On an international scale, jobs that need not be done in high-cost metropolitan areas could move to low-cost regions in the same country are equally amenable (at least technically) to being performed outside the country in low-cost countries. The wave of services offshoring predicted more than a decade ago (Blinder, 2009) only materialised partially; "telemigration" (Baldwin, 2019) or virtual offshoring may change that. Instead of the workplace moving across country borders based on cost, lower-paid foreign teleworkers would carry out the jobs formerly carried out by higher-paid native workers. This might confound trends in pay differentials which have tended to favour symbolic analyst-type, high-paid white collar jobs – teleworkable – vis a vis jobs requiring local, physically present, workers – plumbers, nurses, especially in a context of restricted international mobility. A development on this scale would raise issues at the EU level about employment relations, taxation, working conditions, and ultimately about the trends in regional convergence.

Teleworking also has environmental implications. By reducing pollution associated with commuting and work travel, it can help employers and governments meet their carbon emissions commitments. However, the net benefit for the environment will depend on the emissions associated with heating and cooling of homes. Here too, environmental policy could consider teleworking and improving energy efficiency of houses as part of their policies to reduce emissions. Employees may also be motivated individually by climate change considerations to minimise their carbon footprint.

From the employee side, a broader availability of remote working may contribute to better job quality and work-life balance for some, especially for those in households with high work intensity, while eliminating hours of unproductive commuting. The evidence from real-time surveys is that employees are positive about remote working and that those that have started teleworking during the COVID-19 crisis would ideally like to working partly from home, partly from the employer workplace in the future. Teleworking may also help improve labour market participation for those with caregiving responsibilities, and those living outside urban areas, by expanding employment opportunities.

There are several reasons for employers, employees, and governments to expand telework. What are the factors that may inhibit such a development? First, aside from the nature of work and work tasks in a given occupation, there are other variables that influence teleworkability. Much work that can be teleworked is reliant on good quality ICT connections. The degree of ICT readiness, including prevalence of computer and internet use and literacy as well as broadband availability, in the country as well as employers providing the necessary access and computer hardware in individual organisations are important enablers. Based on the European Commission's Digital Economy and Society Indicators, it is obvious that there is a wide variation in ICT readiness across different EU member states, which policymakers have a role in addressing.

Variations in ICT-readiness should serve to qualify estimates of the theoretical extent of teleworkability based on the occupational teleworkability index developed in this paper; though again what is striking is that existing incidence of teleworking (and teleworkability) tends to correlate strongly with ICT readiness at national level. Telework is more likely in countries with

developed IT / broadband infrastructure where the Nordic countries for example in particular rank high. It is much less prevalent in Bulgaria and Romania where such provision is more limited.

Spatial variation in ICT maturity is likely to have a strong regional dimension in addition to the cross-national dimension. Intra-country differences in broadband availability for example tend to be large between the main metropolitan areas and rural or provincial towns and villages. More teleworking could offer a part-solution to the problem of unbalanced regional growth (Hurley et al., 2019), facilitating the dispersion of knowledge-based work outside large cities, but only where supporting infrastructure was available on an equal basis in rural and metropolitan areas alike. The COVID-19 crisis has made it clear how communications infrastructure is a public good with strong positive externalities; those with limited or partial access become de facto second-class citizens, the areas in which they live second-class regions. Where connectivity is not a problem, other technical issues may complicate a broader expansion of telework. Network security is probably easier to manage in a centralised than a distributed workplace. With sensitive information – customer databases, product designs – increasingly digital, telework may offer new vulnerabilities to digital intrusion and IP theft.

Other obstacles to broader take-up relate to work organisation, work culture, and industrial relations. Pre-outbreak telework was largely the preserve of professionals and managers in knowledge-based service sectors. It was mainly for this group of workers that (mostly occasional) telework access has been developed: partly as a benefit, as a badge of trust. Employers use it to recruit high-flying employees, as well as compensation for (and encouragement to) professional over-commitment. Employers prefer to monitor less qualified or less experienced employees in order to ensure they are not 'shirking' and this is done in part by compelling their presence at the employer's premises. National labour laws – and institutions for social dialogue and industrial relations systems – have developed around work on-premises. As a result, trade unions may be wary of moves to disperse workers, which can weaken their rights and bargaining power towards employers.

Employers may extend their capacity to monitor and supervise work wherever it is carried out. Indeed, employees may be more 'visible' when working remotely online than when working physically at the workplace. Anecdotal and journalistic evidence suggests that with the massive expansion of telework during the COVID crisis there has also been a big increase in employers´ interest in remote worker monitoring tools.[19] The task content of work and its organisation may also change under telework: splitting tasks in smaller units for easier monitoring, fragmenting and collecting more data on performance, potentially increasing intensity and pace of work, and extending working hours.

While real-time survey evidence points to employees being positive about teleworking both during the crisis and prospectively, they also pointed to a number of potential negative issues. Less immediate access to colleagues may mean greater difficulties in team-working, mentoring or on-the-job learning, support, and lower levels of informal co-operation. As innovation in many knowledge-based organisations relies on these social interactions, these are not just inconveniences for individual workers – especially young professionals, who develop human and social capital in the workplace early in their careers – but are potentially damaging to individual and organisation level performance. In the past, the importance to productivity of worker co-presence has been cited by knowledge-industry managers as motivations for scaling down telework initiatives (Arthur, 2013).

[19] Among the web-based applications to attract publicity during the lockdown was the aptly named www.sneek.io, which offers employers and employees a window on their fellow employees' presence in front of their laptops by taking web-cam shots up to every half-minute and indicating the work status availability of individual employees. This allows 'human contact for remote teams'.

Equally, there is a rich economic geography literature on the positive externalities that come from proximity of knowledge-based workers in larger cities (for example, see Glaeser 2011, Moretti 2012). These positive externalities include for example knowledge transfer and creative learning at the organisation level and "thick labour markets" with plentiful and diverse skill profiles at the macro-level. One could extend the list to include positive social spillovers in networking, social connections, tacit knowledge exchange as well as even less accountable considerations such as social amenity and solidarity or esprit de corps. To date, these positive externalities have tended to outweigh considerations such as cost and congestion in the cities in which much of this work has tended to concentrate in advanced labour markets. Any estimate of the likely future incidence of teleworking should not underestimate the power of these centripetal forces: that work is in many ways a social and collective endeavour that needs to take place in a specific location.

Another misgiving regarding telework relates to the difficulty of separating working and non-working life. The fact that both work and domestic responsibilities co-exist in the same physical space necessarily blurs such boundaries, and may increase work-related stress and psychosocial risk. Already, pre-crisis, the risks associated with constant connectivity had prompted four member states to legislate on the 'right to disconnect' (Vargas Llave and Weber, 2020). With a higher prevalence of telework, this becomes an even more compelling policy consideration. The flexibility to work outside the regular workplace and in many cases asynchronously has tended in practice to be associated with longer, more asocial and more irregular working hours. In the context of the COVID-19 pandemic, for many working parents with the added complications of caring for and educating children, the return to the office or workplace post-outbreak may be greeted with relief – also depending on access to adequate childcare and school support. And many single working adults – isolated from their dominant social ambit – may share this relief. Evidence from Eurofound's real-time survey shows that teleworking during the COVID-19 crisis has exacerbated the 'double burden' amongst working mothers in particular (Mascherini and Bisello, 2020). From this vantage, the return to work and the physical separation of home life and working life may be seen as the resumption of a healthy norm.

Conclusions

One of the main arguments in this report is that the share of work that could be carried out remotely is much greater than the pre-outbreak prevalence of teleworking, which was marginal in most countries. Early evidence on what happened from March 2020 onwards supports this contention. Telework provided work continuity for millions of employees and thousands of businesses in the EU and helped preserve employment relationships that might otherwise have been lost. As a form of labour market adjustment to an unprecedented social and economic crisis, it involved as least as many people as state schemes to extend unemployment entitlements or introduce temporary wage subsidies or short-time working. The labour market consequences of the crisis would have been much more severe without the readiness and capability of organisations and companies to adopt to remote working; one can speculate that governments in advanced economies might have taken less restrictive lockdown measures if the alternative of teleworking had not existed. Most governments explicitly recommended telework to businesses as a temporary modus operandi and most businesses that could transition to telework did so – with knowledge-based services sectors heavily over-represented in this group, as shown in this paper.

Estimates of the share of teleworking during the crisis in advanced economies range from around a quarter to two-thirds of employment depending on the country. In all cases, this was a multiple of the pre-crisis incidence of teleworking with most of the increase occurring amongst employees rather than the self-employed. This underlines the fact that, for nearly all employees, workplace attendance is a core obligation, one that was previously waived only on a quite selective basis, and that was lifted on a large scale only in the extraordinary circumstances of a pandemic.

The wide variation across countries tends to reflect pre-outbreak prevalence of teleworking with some countries – notably the Benelux and Nordic countries – registering much higher incidences than, for example, Southern or Eastern European countries. Such differences were only partly accounted for by differences in industrial structure between member states; other factors play a role including occupational composition within sectors and more generally the distribution of employment by firm size, workers' and firms' digital capabilities as well as organisation and management cultures. Teleworking pre-crisis was markedly higher amongst experienced employees in white-collar occupations, often in knowledge-based services. It is also amongst this category that the highest incidences were reported in COVID-19 real time surveys. However, post-outbreak workplace adjustments have also extended the reach of telework especially among younger and lower-qualified white-collar employees – who, before the outbreak, had little experience with telework despite the fact that their work tasks are often amenable to remote working.

What are the implications of this ad-hoc experiment in mass telework for the future of teleworking and its distributional consequences? To the extent that this episode is assessed positively by employees and employers, it may extend access to telework within knowledge-based organisations for all employees whose jobs mainly involve information manipulation regardless of occupational status. It may be levelling in this respect. But the starkest difference according to all evidence gathered in this report was the broader one between white-collar – largely teleworkable – and blue-collar employment – with limited potential teleworking capability. This is based on survey evidence during the crisis and pre-crisis and came across even more clearly in assessments of teleworkability based on the task characteristics of occupations.

These occupational cleavages in teleworking, which there is good reason to suspect will persist, are reflected in dramatic differences by wage and by education level in teleworkability. Nearly three quarters of those in the top wage quintile could potentially telework compared to around one in twenty in the bottom wage quintile according to our occupational teleworkability indicator. Those with third-level qualifications have been around three times as likely to telework as those without.

The salience of "digital divide" as a policy concern has waned over the last decade. This has occurred in tandem with declining cost and widespread access to internet use including via new hardware such as smartphones. However, what has been observed in the spring of 2020 is the

emergence of a new divide between those who can telework and those who cannot. Workers who can telework are those that during the COVID-19 crisis were more likely to be still in employment, more likely to have worked the same or similar working hours as pre-outbreak and less likely to have suffered declines in income than those who were not telework-capable. The telework divide was less evident before the crisis mainly because the incidence of teleworking remained marginal.

To the extent that telework becomes more prevalent, as many predict, this new divide could tend to increase spatial and social separation between social classes. As Durkheim argued many years ago, (physical) work provides a source of organic solidarity between classes and a mechanism of social integration and mixing. If an aristocracy of labour separates out to an upper sphere of virtual remotely provided labour, social distances potentially become much larger, social cohesion more problematic.

In contrast, nearly two-thirds of workers remain tied to their workplaces rendering telework difficult or impossible. During the COVID-19 crisis, many such occupations – health and personal care workers, manufacturing and agriculture workers involved in food provision, retail workers – have been the ”essential” workers, their social utility more than ever obvious and recognised and calls for this to be made good by higher pay in a post-outbreak social settlement (Cominetti et al, 2020). This has been sharpened by the added exposure to serious health risk that their work has involved. There has been some expansion of teleworking solutions in the areas of remote medical consultations and teaching for example, but the majority of such work will remain place-dependent. Access to telework will remain structurally unequal for this reason, between ‘remotes’ (Reich, 2020) whose work lends itself to telework and the remainder, including many ‘essentials’, for whom it is largely not an option.

References

Adams-Prassl, A., Boneva, T., Golin M. and Rauh C. (2020), *Inequality in the Impact of the Coronavirus Shock: Evidence from Real Time Surveys* (version dated: 28/4/2020). Link: https://drive.google.com/file/d/1JYI4bzQ5ytmml_Vct8o-Zw7BqRsHKzsq/view

Ahrendt, D., Sandor, E., Leoncikas, T., Wilkens, M. and Mascherini, M. (2020), Living, working and COVID-19: Methodological note of wave 1 (of survey), Dublin: Eurofound. Link: https://www.eurofound.europa.eu/publications/report/2020/living-working-and-covid-19#wp-100605

Arthur, C. (2013), "Yahoo chief bans working from home", Guardian 25/2/2013. Accessed at https://www.theguardian.com/technology/2013/feb/25/yahoo-chief-bans-working-home on 11/6/20.

Baldwin, R. (2019). The globotics upheaval: Globalization, robotics, and the future of work. Oxford University Press.

Barrot, J.-N., B. Grassi, and J. Sauvagnat (2020): "Sectoral effects of social distancing," Working paper, SSRN.

Belot, M., Choi, S., Jamison, J. C., Papageorge, N. W., Tripodi, E., & van den Broek-Altenburg, E. (2020). Six-Country Survey on Covid-19.

Bergamini, E. (2020), How COVID-19 is laying bare inequality (Bruegel blog post). Link: https://www.bruegel.org/2020/03/how-covid-19-is-laying-bare-inequality/

Blinder, A. S. (2009). How many US jobs might be offshorable?. *World Economics*, *10*(2), 41.

Boeri, T, A Caiumi and M Paccagnella (2020) "Mitigating the work-safety trade-off," *Covid Economics: Vetted and Real-Time Papers* 2, 8 April.

Brynjolfsson, Erik, and Andrew McAfee. *The second machine age: Work, progress, and prosperity in a time of brilliant technologies*. WW Norton & Company, 2014.

Cetrulo, A, Guarascio, D., Virgillito, M. E. (2020), "The privilege of working from home at the time of social distancing", Intereconomics 2020:3: 142-147.

Cetrulo, A.; Guarascio, D.; Virgillito, M. E. (2019), Anatomy of the Italian occupational structure: concentrated power and distributed knowledge, GLO Discussion Paper, No. 418, Global Labor Organization (GLO), Essen.

Dingel, J and B Neiman (2020) "How Many Jobs Can be Done at Home?," *Covid Economics: Vetted and Real-Time Papers* 1, 3 April.

Eurofound (2020), Living, working and COVID-19: First findings – April 2020, Dublin. Link: https://www.eurofound.europa.eu/publications/report/2020/living-working-and-covid-19-first-findings-april-2020

Fana, M, Tolan, S, Torrejón, S, Urzi Brancati, C and E Fernández-Macías (2020), "The COVID confinement measures and EU labour markets", EUR 30190 EN, Publications Office of the European Union, Luxembourg. ISBN 978-92-79-18366-2, doi:10.2760/69199, JRC120578.

Fernández-Macías, E., Hurley, J. and Bisello, M. (2016), What do Europeans do at work? A task-based analysis (European Jobs Monitor 2016), Publications Office of the European Union, Luxembourg.

Fernández-Macías, E. (2018). Automation, digitalisation and platforms: Implications for work and employment. Eurofound Working Paper.

Fernández-Macías, E., Klenert, D., Antón, J. (2020). *Not so disruptive yet? Characteristics, distribution and determinants of robots in Europe*. JRC Working Papers on Labour, Education and Technology, No. 2020/01. Seville: Joint Research Centre, European Commission.

Frey, C. B., & Osborne, M. A. (2017). The future of employment: How susceptible are jobs to computerisation?. *Technological forecasting and social change*, *114*, 254-280.

Glaeser, E. (2011). Cities, productivity, and quality of life. *Science*, *333*(6042), 592-594.

Gottlieb, C and J Grobovsek and M Poschke (2020) "Working from Home Across Countries," *Covid Economics: Vetted and Real-Time Papers* 8, 22 April.

Guyot, K. and Sawhill, I. (2020), "Telecommuting will likely continue long after the pandemic", Brookings Institution web posting (dated: 6/4/2020). Link: https://www.brookings.edu/blog/up-front/2020/04/06/telecommuting-will-likely-continue-long-after-the-pandemic/

Hurley, J., Fernández-Macías, E., Bisello, M., Vacas-Soriano, C. and Fana, M. (2019), European Jobs Monitor 2019: Shifts in the employment structure at regional level, European Jobs Monitor series, Publications Office of the European Union, Luxembourg.
ILO (2020) "Defining and measuring remote work, telework, work at home and home-based work". ILO policy brief.

Mascherini, M. and Bisello, M. (2020), Covid-19 fallout takes higher toll on women, Social Europe (23/6/20). Link: https://www.socialeurope.eu/covid-19-fallout-takes-higher-toll-on-women

McCarthy, A., Ahearne, A., Bohle Carbonell, K., Ó Síocháin, T. and Frost, D. (2020). Remote Working During COVID-19: Ireland's National Survey Initial Report. Galway, Ireland: NUI Galway Whitaker Institute & Western Development Commission.

Mandl, I., Curtarelli, M., Riso, S., Vargas, O. and Gerogiannis, E. (2015), New forms of employment, Publications Office of the European Union, Luxembourg

Messenger, J., Vargas Llave, O., Gschwind, L., Boehmer, S., Vermeylen, G. and Wilkens, M. (2017), Working anytime, anywhere: The effects on the world of work, Publications Office of the European Union, Luxembourg, and the International Labour Office, Geneva. http://eurofound.link/ef1658

Messenger, J. (ed) (2019), Telework in the 21st century: an evolutionary perspective, ILO / Edward Elgar. Link: https://www.ilo.org/global/publications/books/WCMS_723395/lang--en/index.htm

Möhring, K., Naumann, E., Reifenscheid, M., Blom, A.G., Wenz, A., Rettig, T., Lehrer, R., Krieger, U., Juhl, S., Friedel, S., Fikel, M., Cornesse, C. (2020), *Die Mannheimer Corona-Studie: Schwerpunktbericht zur Erwerbstätigkeit in Deutschland* (period covered: 20.3.-15.4.2020), Mannheim Corona Survey, Focus report: Employment in Germany. Link: https://www.uni-mannheim.de/en/gip/corona-study/.

Moretti, E. (2012). *The new geography of jobs*. Houghton Mifflin Harcourt.

Murphy, H. (2020), "Facebook to shift permanently to a more remote workforce", Financial Times 21/5/20. Accessed at https://www.ft.com/content/4ae2fdf7-f427-4e98-abd7-feeb6b6f43f2 on 11/6/20.

Newport, C. (2020), "Why Remote Work Is So Hard—and How It Can Be Fixed", The New Yorker. https://www.newyorker.com/culture/annals-of-inquiry/can-remote-work-be-fixed

Nilles, J. M. "The Telecommunication-Transportation Tradeoff: Development of Policy." (1976).

Office of National Statistics (2020a), Coronavirus and the social impacts on the countries and regions of the UK, April 2020 (statistical bulletin).

Office of National Statistics (2020b), Coronavirus and homeworking in the UK labour market: 2019, London: ONS.

Pouliakas, K; Branka, J (2020). EU jobs at highest risk of Covid-19 social distancing: Is the pandemic exacerbating the labour market divide? Luxembourg: Publications Office of the European Union. Cedefop working paper; No 1. http://data.europa.eu/doi/10.2801/968483

Reich, R. (2020), "Covid-19 pandemic shines a light on a new kind of class divide and its inequalities**"**, *The Guardian* (26/4/20). Link: https://www.theguardian.com/commentisfree/2020/apr/25/covid-19-pandemic-shines-a-light-on-a-new-kind-of-class-divide-and-its-inequalities

Sandler, R. (2020), "Half Of Facebook's Employees May Permanently Work From Home By 2030, Zuckerberg Says", Forbes online (21/5/2020). Link: https://www.forbes.com/sites/rachelsandler/2020/05/21/half-of-facebooks-employees-may-permanently-work-from-home-by-2030-zuckerberg-says/#15dcdc684c4a.

Schoenenberg, K., Raake, A., & Koeppe, J. (2014). Why are you so slow?–Misattribution of transmission delay to attributes of the conversation partner at the far-end. *International Journal of Human-Computer Studies*, *72*(5), 477-487.

Schwind, L. and Vargas Llave, O. (2019), "Telework and its effects in Europe", in Messenger, J (ed.) (2019).

Toffler, A. (1980). The third wave/Alvin Toffler. *New York: Morrow*.

US Federal Reserve Board (2020), Report on the Economic Well-Being of U.S. Households in 2019, Featuring Supplemental Data from April 2020. Link: https://www.federalreserve.gov/consumerscommunities/shed.htm

Vargas Llave, O., Mandl, I., Weber, T. and Wilkens, M. (2020), Telework and ICT-based mobile work: Flexible working in the digital age, New forms of employment series, Publications Office of the European Union, Luxembourg https://www.eurofound.europa.eu/publications/report/2020/telework-and-ict-based-mobile-work-flexible-working-in-the-digital-age

Vargas Llave, O. and Weber, T. (2020), Regulations to address work–life balance in digital flexible working arrangements, New forms of employment series, Publications Office of the European Union, Luxembourg

Annexes

Constructing the technical teleworkability index[20]

The technical teleworkability index is based primarily on the *Indagine Campionaria delle Professioni*, an Italian occupation survey that follows closely the structure of the American O*Net survey. We used the detailed information on tasks in this survey to classify fine-grained occupations (over 750 5-digit occupations in the Italian professional classification) as technically teleworkable or not, based on the amount of physical interaction captured by six variables, covering most of the spectrum of physical tasks.

For analytical simplicity, we opted to classify occupations based on a single threshold: each 5-digit occupation is classified as not teleworkable whenever the importance score reported in the survey of any of the seven physical tasks indicators exceeds a value of 40, and as teleworkable otherwise. We settled on a value of 40 on the importance scale because it divided most accurately those occupations that involve manual and physical tasks, from those that do not – as shown by the distribution of the importance scores of each of the six variable from ICP, presented in Figure 25 below. The plot shows the density distribution of the importance scores for all 5-digit occupations, divided by one-digit occupation major group. For managerial, professional, and clerical occupations, the bulk of the distribution (i.e., most 5-digit occupations) are to the left of the 40 threshold (the dashed line) for manual dexterity, finger dexterity, general physical activity, and handling and moving objects. Most craftspeople, plant and machine operators and assemblers, and a significant share of technical professionals report values higher than 40 for inspecting equipment, structures, and materials.

In addition to the six physical interaction variables contained in ICP, we also drew from the European Working Conditions Survey to add an additional physical interaction variable providing information on another type of physical interaction not covered in ICP, namely the frequency of lifting or moving people. As shown in Figure 26, the values of this indicator are zero or very low for most ISCO 3-digit occupations, but there is a distinct cluster of occupations for which it is high, mostly in health and social care. As it happens, the value for *Child care and teacher's aides* (ISCO 531) fell slightly below the threshold of 40. Because this occupation has clearly much in common with all the other caring professions that report physically handling people, we decided to include it among the not teleworkable.

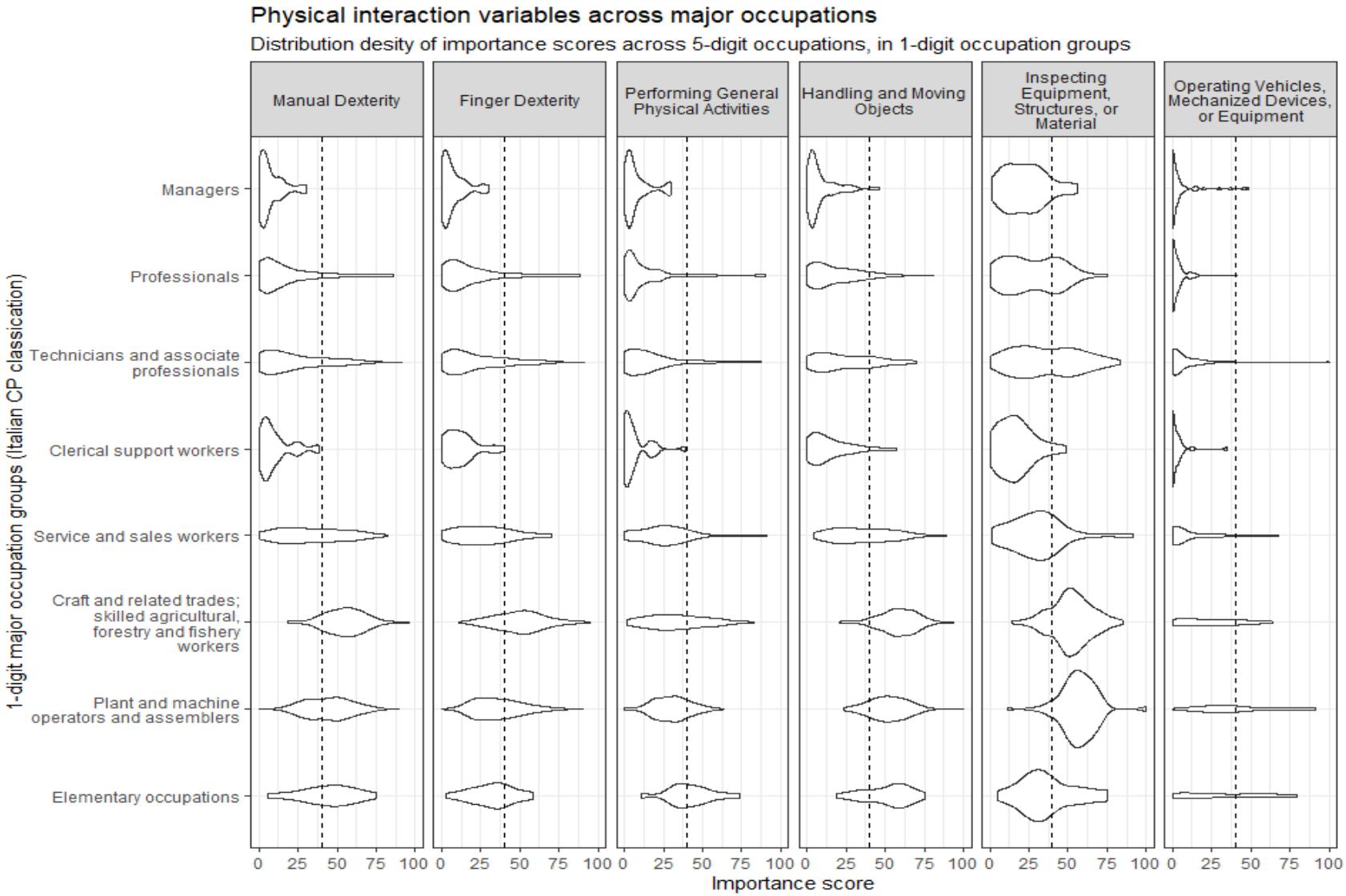
We made another ad-hoc adjustment for cashiers in retail (CP 5.1.2.4.0, part of ISCO 523), who reported values at or below 34.8 for all physical interaction variables, including 30.4 for Handling and Moving Objects. These values appeared implausible, not only in comparison with similar occupations like ticket sellers, but also with the task descriptions of that occupation, reported in a dedicated section of the ICP. We decided to override the data-driven classification of ISCO 523, and marked them as *not* teleworkable.

Finally, we duplicated the values of ISCO *322: Nursing and Midwifery Associate Professional* into ISCO *222: Nursing and Midwifery Professional*, because the official CP to ISCO mapping of occupations did not distinguish between the two.

All these changes are commented and reported in the code to construct the indicators.

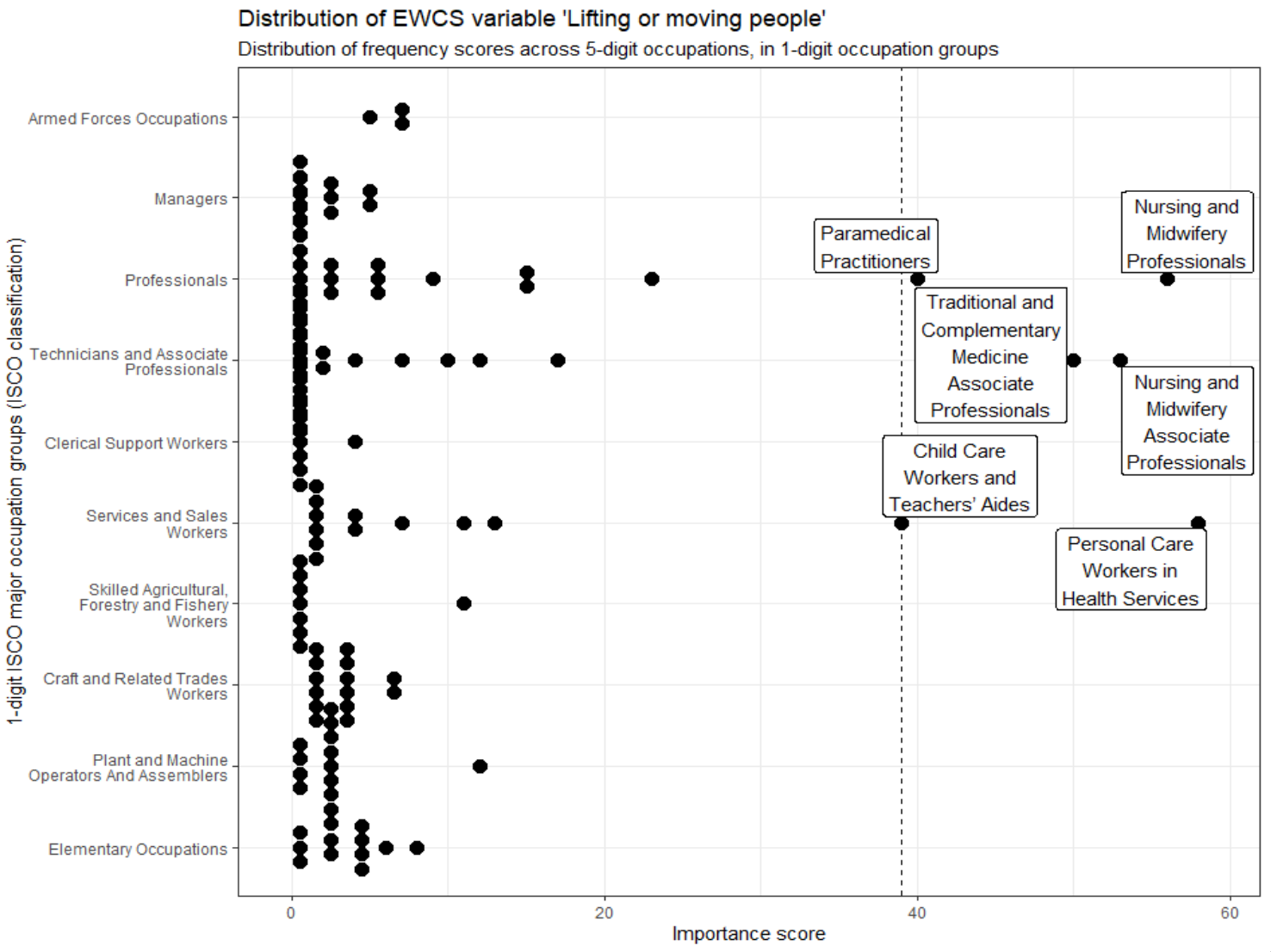
[20] The code to construct the indices is available at https://github.com/m-sostero/telework-occupations

Figure 26: Values of technical teleworkability variables from ICP survey



The figure shows the density distribution plot for the values of physical interaction variables across 798 different CP 5-digit occupations, divided by 1-digit occupation major groups. Wider sections of the density curves mean that more occupations are clustered around that value of the importance score. The dashed line represents the threshold used to classify the technical teleworkability of occupations.

Figure 27: Distribution of physical interaction variable "Lifting or moving people" from EWCS



The figure shows the distribution of the values of Lifting or moving people for 129 different ISCO 3-digit occupations, divided by 1-digit occupation major groups. The dashed line represents the threshold used to classify the technical teleworkability of occupations.

Values of technical teleworkability and social interaction indices

The table below shows the values of the technical teleworkability and social interaction indices for ISCO 2008 3-digit occupation groups.[21]

ISCO08 code	Occupation title	Technical teleworkability	Social interaction
111	Legislators and senior officials	1.00	0.68
112	Managing directors and chief executives	1.00	0.69
121	Business services and administration managers	1.00	0.61
122	Sales, marketing and development managers	1.00	0.65
131	Production managers in agriculture, forestry and fisheries	0.00	0.62
132	Manufacturing, mining, construction, and distribution managers	0.18	0.62
133	Information and communications technology service managers	1.00	0.57
134	Professional services managers	1.00	0.67
141	Hotel and restaurant managers	0.97	0.63
142	Retail and wholesale trade managers	0.07	0.67
143	Other services managers	0.89	0.61
211	Physical and earth science professionals	0.23	0.45
212	Mathematicians, actuaries and statisticians	1.00	0.59
213	Life science professionals	0.26	0.54
214	Engineering professionals (excluding electrotechnology)	0.25	0.50
215	Electrotechnology engineers	0.00	0.51
216	Architects, planners, surveyors and designers	0.38	0.36
221	Medical doctors	0.39	0.79
222 [22]	Nursing and Midwifery Professionals	0.00	0.94
225	Veterinarians	0.00	0.64
226	Other health professionals	0.59	0.75
231	University and higher education teachers	0.49	0.80

[21] The table is available in csv format at https://github.com/m-sostero/telework-occupations

[22] Value duplicated from *322: Nursing and midwifery associate professionals*, because the official CP-ISCO mapping does not distinguish between the two.

232	Vocational education teachers	1.00	0.76
233	Secondary education teachers	1.00	0.77
234	Primary school and early childhood teachers	0.61	0.78
235	Other teaching professionals	0.86	0.74
241	Finance professionals	1.00	0.46
242	Administration professionals	0.97	0.57
243	Sales, marketing and public relations professionals	1.00	0.56
251	Software and applications developers and analysts	1.00	0.46
252	Database and network professionals	1.00	0.41
261	Legal professionals	1.00	0.43
262	Librarians, archivists and curators	1.00	0.51
263	Social and religious professionals	0.98	0.67
264	Authors, journalists and linguists	1.00	0.43
265	Creative and performing artists	0.34	0.54
311	Physical and engineering science technicians	0.01	0.45
312	Mining, manufacturing and construction supervisors	0.00	0.57
313	Process control technicians	0.02	0.38
314	Life science technicians and related associate professionals	0.63	0.35
315	Ship and aircraft controllers and technicians	0.09	0.60
321	Medical and pharmaceutical technicians	0.00	0.39
322	Nursing and midwifery associate professionals	0.00	0.94
324	Veterinary technicians and assistants	0.00	0.39
325	Other health associate professionals	0.35	0.66
331	Financial and mathematical associate professionals	1.00	0.41
332	Sales and purchasing agents and brokers	1.00	0.66
333	Business services agents	1.00	0.52
334	Administrative and specialised secretaries	1.00	0.53
335	Regulatory government associate professionals	0.53	0.57
341	Legal, social and religious associate professionals	1.00	0.74
342	Sports and fitness workers	0.04	0.67

343	Artistic, cultural and culinary associate professionals	0.11	0.48
351	Information and communications technology operations and user support technicians	0.93	0.43
352	Telecommunications and broadcasting technicians	0.00	0.32
411	General office clerks	1.00	0.39
412	Secretaries (general)	1.00	0.44
413	Keyboard operators	1.00	0.29
421	Tellers, money collectors and related clerks	0.93	0.50
422	Client information workers	1.00	0.48
431	Numerical clerks	1.00	0.26
432	Material-recording and transport clerks	0.40	0.42
441	Other clerical support workers	0.82	0.40
511	Travel attendants, conductors and guides	0.73	0.78
512	Cooks	0.00	0.48
513	Waiters and bartenders	0.00	0.56
514	Hairdressers, beauticians and related workers	0.00	0.58
515	Building and housekeeping supervisors	0.00	0.70
516	Other personal services workers	0.32	0.55
521	Street and market salespersons	0.00	0.84
522	Shop salespersons	0.04	0.80
523 [23]	Cashiers and ticket clerks	0.10	0.51
524	Other sales workers	0.33	0.50
531 [24]	Child care workers and teachers' aides	0.00	0.75
532	Personal care workers in health services	0.00	0.54
541	Protective services workers	0.40	0.57
611	Market gardeners and crop growers	0.00	0.43
612	Animal producers	0.00	0.33
613	Mixed crop and animal producers	0.00	0.36
621	Forestry and related workers	0.00	0.46

[23] Value for the main subgroup (CP 5.1.2.4.0) changed manually from teleworkable to non teleworkable.

[24] Value just below the threshold, moved from teleworkable to non teleworkable.

622	Fishery workers, hunters and trappers	0.00	0.41
711	Building frame and related trades workers	0.00	0.27
712	Building finishers and related trades workers	0.00	0.38
713	Painters, building structure cleaners and related trades workers	0.00	0.31
721	Sheet and structural metal workers, moulders and welders, and related workers	0.00	0.38
722	Blacksmiths, toolmakers and related trades workers	0.00	0.32
723	Machinery mechanics and repairers	0.00	0.33
731	Handicraft workers	0.00	0.36
732	Printing trades workers	0.33	0.30
741	Electrical equipment installers and repairers	0.00	0.40
742	Electronics and telecommunications installers and repairers	0.00	0.42
751	Food processing and related trades workers	0.00	0.50
752	Wood treaters, cabinet-makers and related trades workers	0.00	0.37
753	Garment and related trades workers	0.00	0.36
754	Other craft and related workers	0.00	0.36
811	Mining and mineral processing plant operators	0.00	0.27
812	Metal processing and finishing plant operators	0.00	0.33
813	Chemical and photographic products plant and machine operators	0.00	0.30
814	Rubber, plastic and paper products machine operators	0.00	0.28
815	Textile, fur and leather products machine operators	0.25	0.31
816	Food and related products machine operators	0.00	0.33
817	Wood processing and papermaking plant operators	0.00	0.35
818	Other stationary plant and machine operators	0.00	0.29
821	Assemblers	0.00	0.26
831	Locomotive engine drivers and related workers	0.00	0.18
832	Car, van and motorcycle drivers	0.00	0.52
833	Heavy truck and bus drivers	0.00	0.18
834	Mobile plant operators	0.00	0.25

835	Ships' deck crews and related workers	0.00	0.26
911	Domestic, hotel and office cleaners and helpers	0.00	0.32
912	Vehicle, window, laundry and other hand cleaning workers	0.00	0.45
921	Agricultural, forestry and fishery labourers	0.00	0.24
931	Mining and construction labourers	0.00	0.19
932	Manufacturing labourers	0.00	0.24
933	Transport and storage labourers	0.00	0.20
941	Food preparation assistants	0.00	0.26
951	Street and related service workers	0.00	0.43
952	Street vendors (excluding food)	0.00	0.71
961	Refuse workers	0.00	0.29
962	Other elementary workers	0.28	0.36

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