Gaps between working from home and its feasibility over time and across occupations

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Abstract

Exploiting rich working conditions surveys available since 1991 and the French Labor Force Survey since 2003, we provide a historical analysis of the gaps between Working From Home (WFH) and its feasibility. We compare the actual prevalence of WFH over the period to its predicted feasibility, based on a machine learning model evaluated in 2021 and detailed data on jobs' task contents. Predicted WFH feasibility has continuously and substantially increased over the period from 10% in 1991 to 45% in 2021. Meanwhile, actual WFH practices remained limited. Only 10% of jobs that could be done from home were indeed teleworked before 2016. This share increased in the few years before Covid 19, up to 20% in 2019, before jumping to 50% in 2021. Employees work from home much less than executives and managers compared to their potential. This is remarkably true both before and after Covid. These gaps can only be partly explained by differences in organisational and management practices (hierarchical control and autonomy) across occupations. They are not explained by differences in workers' desire to WFH. This implies that the well-known large inequality in access to WFH along the earnings distribution cannot be attributed only to feasibility or organisational constraints.

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1 Introduction

The COVID-19 pandemic has triggered a massive shift toward working from home (WFH) and, at the same time, intense debates regarding the quantitative importance of this shift and whether it will be permanent or temporary. Recent research has tried to evaluate both the share of jobs that can be done from home in the modern economy (e.g. Dingel and Neiman, 2020) and the likelihood that the high levels of WFH observed during the pandemic will persist (e.g. Barrero et al., 2021).

We contribute to these debates by examining the long-run evolution of the working practices that make WFH feasible in France. Doing so, we can assess how the task composition of labor has changed over time and if the share of jobs that can be done from home has increased slowly or rapidly over the past 30 years. This in turn allow us to study gaps between actual WFH and its feasibility over time and across occupations and to better understand if WFH is and has been mostly limited by technical feasibility constraints. This historical approach contribute to informing the debate on the likelihood that WFH will be widespread in the future.

To study the evolution of working practices (or tasks) that make WFH feasible, we first need to identify them. Following Hatayama et al. (2020), we consider four types of tasks or factors that can facilitate WFH: (1) the intensity of ICT use at work, (2) the intensity of face-to-face interactions with either colleagues or the public, (3) measures of physical intensity and manual work, and (4) the quality of internet connection at home. We present the evolution of the prevalence of these various fundamental aspects of work since 1991. We then decompose it into within- and between-occupations components. Results show that changes mostly occur within occupations and are not driven by changes in the occupational mix of the labor market.

We then use machine learning (ML) techniques to predict which working practices

can make WFH feasible and validate the relevance of the factors considered in the literature. This is done using a working condition survey containing information on (i) WFH feasability of jobs (self-assessed by survey respondants), (ii) actual WFH, and (iii) the task content of jobs. The survey is administered in early 2021 in France, a period with strong COVID-19 prevalence and specific regulations making WFH was mandatory whenever it could be done. We predict both WFH and WFH feasability by the task content of jobs. As a robustness check, we reproduce this analysis in 2019, just before the COVID-19 crisis, using a richer survey and compare the results of the three prediction exercises. We finally apply these three predictors in either 2021 or 2019 on former surveys that include similar questions, allowing us to examine the evolution since 1991 of WFH feasability and predicted WFH. A strength of this last approach based on ML is to be agnostic regarding the factors that should be considered to assess which jobs can be done from home.

The second contribution of the paper is to provide an analysis of the gap between actual WFH and WFH feasibility across occupations over the recent period. This allows us to identify practical obstacles to WFH, and how they may have been lifted over time. Specifically, we study the evolution of WFH at the occupational-level over the past decade using monthly information from the French labor force survey, and compare it to our measures of WFH feasability aggregated at the occupational level and their evolution over time. Our analysis yields two main insights: first, before the COVID-19 crisis, WFH remained very limited and increased more slowly than WFH feasability. Second, there is a large gap in actual WFH across occupations that cannot be explained by differences in WFH feasability: clerks that were already spending more than 80 % of their time in front of a connected computer in the 2000s are much less likely to work from home than white-collars with otherwise similar working practices. Both results highlight that there are other obstacles impairing WFH than its practical feasibility. To explain the differences across occupations, we use information on workers' desire to work from home to reject supply-side

determinants, and highlight the role of demand-side factors, in particular the opposition of manager to let managees telework. We argue that these managerial obstacles magnifies the already large inequality in WFH feasibility between low- and high-skill workers.

Related literature. Our study relates to a rapidly growing literature on WFH. A first strand of this literature examines which jobs can be done from home. Dingel and Neiman (2020)–DN2020 here after–have developed an axiomatic approach that consists in identifying the types of tasks that make jobs (not) amenable to WFH. Specifically, using O*NET occupation-level surveys for the US, they categorize jobs as "not amenable to telework" if an occupation requires daily work outdoors, physical activity, frequent contact with the public, or operating vehicles, mechanized devices, or equipment, or if its holders use email less than once a month, interact with violent people on a weekly basis, spend the majority of their time walking or running, sustain minor burns or cuts each week, or have to routinely wear specialized protective equipment. They assume that a job cannot be performed from home at all if it meets at least one of these conditions.

Mongey and Weinberg (2020); Gottlieb et al. (2020); Saltiel (2020); Hatayama et al. (2020); Garrote Sanchez et al. (2021), among others, have build on the work of DN2020. Mongey and Weinberg (2020) propose a continuous measure of WFH feasibility. Gottlieb et al. (2020) apply DN2020 to 57 countries and focus on biases induced by categorizing farmers as not working from home in developing countries. Saltiel (2020) and Hatayama et al. (2020) use skills data in several countries to examine if the task content of different occupations vary across countries, making US-based measures à la DN2020 not applicable to other countries. Garrote Sanchez et al. (2021) develop a measure of WFH feasability that also takes into account internet access and apply it to 107 countries.

A last group of papers departs from the task-based approach and uses directly individual-level data on WFH (e.g. Hensvik et al., 2020), or on WFH feasability directly self-assessed

by workers (e.g. Adams-Prassl et al., 2022; Alipour et al., 2023). Alipour et al. (2023) Adams-Prassl et al. (2022) highlight the strong heterogeneity of WFH feasability within occupations or industries, while Alipour et al. (2023) study directly the link between tasks and WFH feasability, showing in particular that a single indicator of PC usage does a good job in predicting WFH capacity. Finally, whatever the method they use, all papers focusing on WFH amenability conclude that it increases with workers' earnings and education levels.

Our contribution relative to these papers is twofold. First, we analyze the evolution over 30 years of the tasks or working practices that make WFH feasible in a developed country. This allows us to estimate how the share of jobs that can be done from home has evolved over time. This approach can be seen as similar in spirit to the work on job polarization that has examined the evolution over time of employment in occupations depending on their task content (e.g. routine versus non-routine tasks, see for example Autor et al. (2003) or Autor and Dorn (2013)). The difference is that we analyze tasks that are amenable to WFH and we have access to direct information on the prevalence of these tasks at work at different points in time.

Second, we rely on two rich working conditions surveys administered just before and during the pandemic to propose alternative, more agnostic, approaches to assess the task content of jobs that are associated with both actual WFH (before and during the COVID crisis) and WFH feasibility. Doing so, we follow and extend the work of Alipour et al. (2023). While they use a linear probability model to link job tasks to WFH feasability, we use a variety of ML techniques that allow us to take into account interactions between predictors and nested effects of the tasks that make WFH feasible. The ML approach is also key to get an accurate predictor of WFH or WFH feasability that we can apply retrospectively without fearing that we are over-fitting the data.

We then relate to the papers that try to assess if WFH will stick durably after the

COVID-19 crisis (Barrero et al., 2021; Bartik et al., 2020; Bick et al., 2021). These papers rely on theoretical arguments typically combined with survey data measuring, during the crisis, workers' desire to keep working from home and employers' plans to maintain it. Our retrospective analysis of the development of working practices that make WFH feasible complement these papers as it can shed light not only on the immediate persistence of WFH but also on the potential for its expansion at an even larger scale in the long run.

Finally, we indirectly relate to the strand of literature that attempts to evaluate how workers and employers value WFH and are willing to pay for it (Mas and Pallais, 2017; Oettinger, 2011; Nagler et al., 2022; Lewandowski et al., 2022).We do so by analyzing the gaps between WFH feasability and actual WFH, combined with information on workers' desire to WFH. We show in particular that gaps between actual WFH and WFH feasibility or workers' desire to work from home vary strongly across occupations.

Organization. The rest of the paper is organized as follows. Section 2 briefly describes the institutional context and presents the data and methods. Section 3.1 analyses the tasks that predict WFH feasability and actual WFH in the recent period. Section 3.2 shows the evolution of these tasks and more boradly of WFH feasability in the labor market since 1991. Section 4 analyzes gaps between actual WFH and WFH feasability before and during the COVID-19 crisis and their determinants. Section 5 wraps up the main results and uses them to discuss the long-run potential for widespread WFH in the economy.

2 Context, data and methods

In this section, we briefly provide contextual information on the development of WFH in France and the regulations in place. We then describe our data and the methods used to analyze it.

2.1 Institutional context

Prior to the Covid-19 crisis, the academic literature on teleworking and working from home arrangements was remarkably scarce. Documenting long-term trends in the prevalence of working from home and teleworking is thus a contribution in itself. Two notable exceptions are Barrero et al. (2023) and de Vos et al. (2019) on the USA and the Netherlands, respectively. The former documents a steady increase in the take up of working from home in the USA since the 1960s, from 0.4 % of days worked from home in 1965 to 7.2 % in 2019, with a massive discontinuous increase in 2020, and a stabilisation around 28 % in 2022. The latter document a higher take-up of working from home arrangements in the Netherlands, the country with the highest take up of working from home arrangements in Europe in 2021; with 22 % of Dutch workers declaring having a home working day in 2018, up from 16 % in 2008 ; this share reached 53 % in 2021.

The definition and measurement of teleworking and working from home arrangements vary across time and space; yet, these definitions matter, both for assessing international or regional differences, and temporal evolutions of the takeup of these practices. A distinction is typically made between *working from home*, which means that a worker employed in a firm is not working within the firm's premises, but rather at her home; and *teleworking*, which also implies remoteness from the firm's premises, albeit not necessarily at a worker's home, as well as the use of information and communication technologies. Whether the definition of teleworking also implies some degree of regularity is important, in particular because of its legal implications. French law defines teleworking more restrictively, by considering only work that could have otherwise been executed within the firm's premises, and only voluntary arrangements; ICT use also enters more restrictively in the French legal definition of teleworking since the worker is required to be reachable by ICT in order to be considered to be teleworking. "Regular" teleworking is subject to more regulations—notably in terms of rights for employees—than occasional or exceptional teleworking.

In Figure 1, we document the evolution of telework and working from home arrangements and highlight the differences across definitions in three series(see section 2.2 for a description of the data sources). The first series represents the share of workers who telework at least sometimes, telework being defined here as the combination of remoteness from the employing firm's premises and usage of ICT. The second series represents the share of workers who declare working at least partly from home during a typical work week. The third series represents the share of workers who declare working at least partly from home during a typical work week, excluding the ones that declare working from home extra hours at night or during week-ends, that are over-represented amongst managers or teachers. "Teleworking" has been increasing in France since the early nineties, with a more rapid increase in the 2010s, prior to the pandemic, reaching about 6 % of the labour force. It increased by more than 15 pp in 2021, reaching 24 % in 2021 before decreasing slightly to 22 % in 2022. Regarding the evolution of WFH prevalence, the absolute increase in 2020 is of similar magnitude, but relative to a much higher baseline at around 17 % in 2019. Similarly, working from home outside regular hours, that is, extra time worked at home, represents a large share of the pre-2020 working from home prevalence.

By contrast to actual teleworking and working from home practices, the potential for teleworking and working from home arrangements has received regular bursts of media and policy attention. The inception of the word "teleworking" dates back to the 1970s, and originates in the engineering literature. Ever since, periods of renewed interest alternate with suggestive evidence that actual teleworking practices are less prevalent than anticipated.

In France, the Breton report (Breton, 1993) is the first instance of teleworking receiving official attention from policymakers[1]. It includes a study by the Insee, which evaluates the

[1]Interestingly, the report originated from the Ministry in charge of land use planning ; historically, one

take-up of telework at the time at 16 000 workers, or 0.1 % of the labour force. Using survey data and projections on the evolution of sectoral and occupational structure of the workforce, it also projects the potential for an increase in telework in the future, with an estimated 200 000 to 300 000 workers practicing teleworking in 2005. Most notably, this projection actually turned out remarkably close to the observed take-up of telework in 2006 at 2 % (Figure 1).

How close "realized" teleworking follows its "potential" has been subject to discussion for decades in non-academic work. In 1992, 54 % of French workers declared being willing to stay home to work at least part of the time if given the chance to do so[2]. In the rest of this paper, we explore the historical discrepancy between teleworking potential and teleworking practices in a data-driven way.

2.2 Data

Working Conditions Surveys 1991-2021. Working Conditions Surveys (*Enquêtes "Conditions de Travail"* in French) are administered by the statistical office (the *Dares*) of the French Ministry of Labor every 6 to 8 years to samples of 15,000 to 25,000 workers since 1991. We have surveys available for years 1991, 1998, 2005, 2013 and 2019. The surveys include an extensive questionnaire which is aimed to capture working conditions in a broad sense: family status, occupation, former career path, work schedule, work intensity, family-life balance, working practices and tasks executed at work, subjective health, psycho-social risks (since 2016) and working from home (since 2019). In addition, the Ministry of La-

of the main source of academic and political interest for teleworking development, both in the US and France, has been connected to road congestion and transport infrastructure.

[2]The question asked to survey respondents reads : "Thanks to modern information and communication technologies, it will be possible, in the future, to work from one's home. As for yourself, would you be willing to stay home and work from there?". The first reason for not being willing to do so is the fear of losing their relationship to coworkers.

bor administered an adapted version of the survey ("Tracov") to 19,953 workers between January 25th and March 7th 2021 to capture the evolution of working conditions during the COVID-crisis. While former regular surveys contained little information of WFH, Tracov includes several questions allowing us to measure both WFH, WFH feasability and workers' desire to WFH. Table **??** provides basic information on each survey (sample size, response rate, main topics included, etc., measures of WFH and teleworking). A challenge for the purpose of this paper is that survey questions are not fully consistent across the whole period 1991-2021. We discuss in Section 2.3 how we address it.

Labor Force Surveys 2003-2022. The Labor Force Survey is run on a quarterly basis by the national statistical institute (Insee) since 1950. It includes some information on whether a worker has worked at least some time from their home in a consistent way since 2003. We use it to compute the evolution of working from home (any time or during regular hours) since 2003. Starting in 2021, detailed questions on *teleworking* are also included.

Archive data on teleworking. Data on teleworking practices is scattered. We use data from Breton (1993), which surveyed the French private sector extensively on teleworking practices in 1993. We also use survey data from the 1997 and 2006 waves of the Numerisation and Organisational Changes survey (*Enquête sur les Changements organisationnels et l'informatisation*) ran by the Insee. The survey samples all private workers in France, and collects information about how often workers work outside of their firms' premises, and their use of ICT.

2.3 Methods

Measures of WFH and WFH feasability. In working condition surveys, say... continuous versus discrete measures + ajouter plus loin si on ajoute les mesures continues

ML prediction. We use as ML algorithm random forests. Among existing prediction methods (LASSO, Trees, Forests, Neural Networks), the forest method is best suited to take into account hierarchies and nested effects between predictors (e.g. WFH is predicted as not feasible if workers exert physical tasks or if they do not but have contact with the public). We provide details on these techniques and the retained tuning parameters in Appendix XX (see also Hastie et al. (2009) for an general introduction on these methods and Varian (2014) or Mullainathan and Spiess (2017) for surveys of applications in economics).

A key point for us is the choice of variables used in the ML algorithms as potential predictors. A first standard issue is the trade-off between overfeeding the ML algorithm with too many irrelevant predictors and cherry-picking the potential predictors . To address it, we provide results based on *all* survey variables in CT2019 and Tracov2021 that measure tasks at work as well as analyses based on regressors that are common to all waves of surveys, considering that questions vary from a wave of the working conditions survey to the next. Table A1, provides the exhaustive list of survey questions capturing tasks and the yearly surveys in which they are included. We design second-best ML predictors that are obtained by feeding the ML algorithms with variables that are present in all waves of the working condition survey only. We provide goodness-of-fit measures of our first-best and second-best ML predictors and estimate the differences in quality between predictors.

Long-run evolution of predicted WFH and WFH feasability. Following our exercise of ML prediction, we retain the main variables characterizing contacts at work, physical activities, use of numerical devices that are (i) available consistently over time, (ii) can be simply interpreted, and (iii) predict well WFH or WFH feasability. We plot their weighted mean for the whole labor force and in each main occupation throughout the studied period. This exercise provides an overview of the evolution of labor market practices that make jobs amenable to telework.

Then denote $f_{2019}^{WFH}(X)$, $f_{2021}^{WFH}(X)$ and $f_{2021}^{WFHfeasability}(X)$ the best "second-best" ML predictors of WFH and WFH feasability depending on individual job tasks X. To show the evolution over time of WFH feasibility and predicted WFH, we hold these functions constant (assuming that the tasks that are amenable to telework do not change over time) and apply them to measures of tasks obtained backward in time. Formally, to illustrate for example the evolution of predicted WFH when the prediction is done in 2021, we show for years $t = 1991, 1998, 2005, 2013$ the empirical counterpart of:

$$\mathbb{E}_{2021}[WFH(t)] = \int f_{2021}^{WFH}(X_t)\, dX_t$$

where X_t are the tasks observed in the economy at date t. Let us clarify that the two predictors of WFH applied backward do not directly provide an estimation of the share of jobs that could be done from home at each examined date. Instead, they inform on the share of jobs that would have been done from home at these dates if the likelihood to work from home depending on the content of a job had been similar to what it is in 2019 and 2021. The results should only be seen as summary measures of the evolution of labor market amenability to WFH. They are then useful to compare this evolution to the actual evolution of WFH in the past decades.

Time series on teleworking. We reconstruct a time series of teleworking since 1993 by interpolating historical data points gathered from various sources (see above). Starting 2002, we also use the a yearly measure of working from home prevalence. This last series exhibits a break in 2013, which impose to retain a less fine-grained but time-consistent measure of working from home prevalence.

Gaps between WFH and WFH feasability. The final step of our analysis is to compare the actual evolution of WFH over the past three decades to the evolution of

its feasability. The objective is to understand if the increased penetration of WFH in the economy has closely followed the removal of feasability constraints, or if instead it should be attributed to other factors (e.g. cultural barriers, management practices, HR opposition). More precisely, we compare the evolution of the actual share of jobs done from home to the following four statistics:

1. The evolution of the share of jobs that can be done from home according to our ML predictor fitted in 2021

2. The evolution of the share of jobs that *would be done from home* if the intensity of WFH recourse given the organizational constraints was that observed during the peak of the COVID-19 pandemic.

3. The evolution of the share of jobs that *would be done from home* if the intensity of WFH recourse given the organizational constraints was that observed in 2019, that is just before the peak of the COVID-19 crisis.

These comparisons allow us to discuss if the main factors behind the evolution of WFH before the COVID-19 crisis are mainly technical (being connected to the Internet) or organizational (ICT use at work, face-to-face interactions, physical intensity of work). Since our ML predictors of WFH feasability and WFH are only available for years $t = 1991, 1998, 2005, 2013, 2019$, we use simple linear interpolations to recover a measure for each year since 1991.

To refine the analysis, we then disaggregate these evolutions and present evidence for each 2-digit occupation separately using the LFS since 2013.

3 Main results

3.1 Predicting WFH and WFH feasibility in the recent period

To predict working from home and its feasibility we resort to machine learning techniques, which offer powerful tools to predict the evolution of a given variable. An additional advantage is that they are almost agnostic methods to rank the importance of potential predictors, and thus prevent issues related to cherry picking variables. They nonetheless present some challenges, which are the choice of the right method, its tuning parameters, and the set of variables fed to the algorithm. For our analysis, we restrict ourselves to one of the most powerful and widely used method: Random Forests. Random Forests is a non linear technique which predicts an outcome as the average prediction of a set of optimized tree classifiers based on randomly drawn features among a set of chosen predictors. Randomly drawing and limiting the set of features prevents from overfitting the model. The number of features randomly drawn is optimized using cross validation. In our case we divide our base sample in five subsamples of equal size and use alternatively four of them to fit the model and one to evaluate the quality of its prediction by computing its mean square error. We eventually chose the model that minimizes this error. For more on the details of the Random Forest technique see Breiman (2001) and Louppe (2015).

Alternative popular ML methods are for example LASSO, Ridge Regressions, Trees, Forests, Gradient Boosting and Neural Networks. Random Forests are better suited than LASSO and Ridge Regressions in our case (and indeed offer better predictions) thanks to the non-linear flexibility they offer. Trees and forests are less sophisticated than random forests and more prone to over fitting, which is also the case of gradient boosting (an extension to Random Forests). Last, neural networks perform potentially better than random forests, but only in large data samples, which is not the case in our analysis where the number of observations varies between 12,000 and 20,000.

We start our analysis by estimating random forests for our variables of interest on the set of all variables that can be thought to be determinants in both the Tracov and CT2019 surveys, which constitute the above-introduced first-best models. To determine their performance, we randomly split our sample in two parts composed of 80 % and 20 % of observations. We then estimate the model on the fist subsample, and predict it on the second. We and use the resulting mean square error (MSE) as our measure for the goodness of fit. We then repeat the procedure for the second-best models estimated on the set of variables common to all surveys and compare the two.

The biggest constraint of our data is the differences between the questions asked in the Working Condition Surveys and those in Tracov. Even though they examine very similar aspects of working conditions, since Tracov has not been designed as a follow up of the Working Conditions survey of 2019, only a limited amount of variables can be defined exactly the same way in both surveys. Luckily, these variables are among those that are retained as the most important for prediction in the full model specification: the share of computer tools in one's occupation, whether the person interacts with the public, and the degree of physical activity.

Table 1 reports the results of our ML models on our three variables of interest: telework feasibility in 2021, telework in 2021 and 2019. The first column displays the results for the first best "full" models, the second one, those for the "restricted" second best models. If we consider the full models, we can notice that overall the models fare well, with MSE smaller than 15 percent. In this context, because the outcome variable to be predicted is an indicator variable, the MSE has a transparent interpretation, as it is equal to the percentage of errors, ie the percentage of observations in the test data that are missclassified. The model on the 2019 Working Conditions survey is exceptionally good at predicting teleworking with only 1.3 % out-of-sample errors. Regarding the selection of the most important variables, the share of computer tools, and contact with others, always

rank among the five most predictive variables. This also the case for the degree of job's physical intensity if we consider the ten most predictive variables.

Moving from first-best to second-best models decrease the accuracy of prediction uniformly, by a relatively small margin. For all three outcomes, the MSE decreases by about 4 percentage points. This has two implications. First, the predictors that we select for conducting our historical analysis capture most of what a full set of observables is able to capture[3]. Second, historical comparisons of the three different outcomes we predict are likely to be meaningful, since the loss in performance is the same for all outcomes.

3.2 The long-run evolution of tasks that make WFH feasible

Next, we study how predicted feasibility has increased since 1991 given the task-mix observed on the labor market at different points in time. Figure 2, panel (a), shows that the share of jobs that can be teleworked has increased strongly over the past 3 decades, from around 8 % in 1991 to more than 45 % in 2021. The increase is close to linear and slightly slows down over time between 1991 and 2019. Feasibility then jumps by more than 10 percentage points between 2019 and 2021. This jump is driven by the adaptation of working practices during the Covid-19 crisis to make teleworking feasible. It shows that the task composition of the economy is endogenous and can be quickly adapted. The scope for adaptation in the short run remains however limited: even in a context of very strong incentives to switch to teleworking during the Covid-19 crisis, teleworking could be made possible for only an additional 10 % of the economy.

Panel (b) of Figure 2 then shows the evolution over time of the key tasks that make teleworking feasible. The most striking feature of this evolution is the continuous increase

[3]In an exercise not shown here, we have compared historical series between a model estimated on about forty variables common to all WC surveys in 2019 and one estimated on our 5 variables common with Tracov. The two series are very close in levels (less than 5 percent difference, and display virtually parallel trends.

of the share of hours worked spent using computers, from 20 % in 1991 to more than 45 % in 2019. This means in particular that slightly less than half of labor input in the French economy was provided in front of a computer before the Covid-19 crisis. The share of hours spent in front of a computer has then jumped to almost 60 % in 2021.

Only 30 % of jobs are not physically demanding, and this share has remained remarkably stable over the past three decades. Finally, the share of jobs requiring to be in contact with the public (e.g. clients, customers, patients) is large and has been slowly increasing from just above 60 % in 1991 to above 70 % in 2019. This trend tends to make teleworking less feasible in the present than in the past. We see however that the extent of contacts with the public has been strongly reduced during the Covid-19 crisis, illustrating that this feature of jobs can be adjusted more rapidly than others when incentives to do so are strong.

4 Gaps between teleworking and teleworking feasibility

In this section, we compare actual teleworking with its feasibility. We do so both over time and across main occupations.

4.1 Comparison of teleworking and teleworking feasibility since 1991

Figure 3, panel (a), provides a direct comparison of teleworking and its feasibility over time. Teleworking has remained very limited compared to its feasibility until the Covid-19 crisis. Even in the Covid-19 period (2021) and the beginning of the post-Covid-19 era (2021), teleworking remained significantly below its predicted (and for the later years,

observed) feasibility. To fully illustrate this point, we plot on panel (b) the ratio and the absolute gap between teleworking and its predicted feasibility. The ratio remained remarkably stable between 1991 and 2016, indicating that teleworking was used for only 10 % of jobs that could be teleworked according to our predictor. In the meantime, the gap between teleworking and its feasibility steadily increased from 10 to 30 percentage points. Interestingly, a change in trend started to occur in 2016, with the ratio between teleworking and its feasibility rapidly increasing from 10 % to 20 % between 2016 and 2019, while the gap stabilized.

The wedge between teleworking and its feasibility has then been reduced further after the advent of the Covid-19 crisis, but it remained substantial: in early 2021, only 50 % of workers who can telework do it at least to some extent, and a gap of 20 percentage points remains between actual teleworking and its declared feasibility.

We conclude from these comparisons that technical and feasibility constraints were not the main drivers that prevented workers from teleworking before the Covid-19 crisis, and that even after the pandemic, teleworking remains largely under-used compared to its feasibility. This conclusion is reinforced by the fact that our measure of teleworking is conservative: workers are counted as teleworkers as soon as they do telework at least half a day per week. Considering measures of teleworking at higher intensity would increase further the gap between teleworking and its feasibility.

Figure 3, panel (a), also compares the evolution of teleworking since 1991 to what it would have been if the intensity of teleworking given the organisational constraints had remained similar to (i) what is observed in 2019 (teleworking predicted from job tasks in 2019), and (ii) what is observed during the COVID-19 pandemic (teleworking predicted from job tasks in 2021). Actual teleworking practices have increased slightly more rapidly -ie, from a lower level in 1991- than we predict based on the tasks and teleworking level observed in 2019. This is largely driven by the late increase in the 2010s,

which is compatible with a gradual removal of non-technical barriers to teleworking during the few years before the pandemic. However, teleworking has increased much more slowly and was much lower than one would predict had the link between tasks and teleworking remained similar to the one observed in 2021. This illustrates that the prevalence of teleworking jumped during the Covid-19 crisis not only because jobs and their task content were adapted, but also, and mostly, because a much larger share of the jobs that could already be done remotely given their task content have started to be done from home.

4.2 Evolution of WFH and WFH feasability by occupation: 2013-2022

Our approach consists in predicting teleworking feasibility only using the task content of jobs. We do not consider individual characteristics nor the type of occupation as possible predictors. The goal is to focus exclusively on feasibility constraints related to the nature of the job. This allows us in turn to study the evolution of these constraints and the gaps between actual teleworking for different occupations.

We aggregate 2-digit occupations in 3 main groups: executives and managers (so-called *Cadres* in French), "connected employees" which includes all clerks or employees that have a teleworking feasibility larger than 50 % in early 2021 (more than 50% of the workers in the occupation declare that their job is teleworkable) and "other workers", who are not managers and have a teleworking feasibility lower than 50 % in 2021 (see Figure A1 for the actual and predicted feasibility within each 2-digit occupation entering these groups).[4] Figure 4, panel (a), shows the evolution of predicted teleworking feasibility for each of these groups obtained using the historical working conditions surveys since 1991. A striking result

[4]We exclude occupations 31 "Independent Workers" 35 "Artists and Entertainement Occupations", 44 "Clergy" and 42 "Teachers" because they are outlier occupations which employees' behavior regarding teleworking can be very different from other occupations' employees. Otherwise, executives are all occupations whose first digit is a "3", while we split the other 2-digit occupations between those with a share of workers declaring their job is feasible from home above or below 50%.

is that feasibility used to be higher for connected employees than for managers. In 1996 for example, 60 % of connected employees could telework, while it was the case only for 35 % of executives. This is largely explained by the early and high prevalence of ICT tools amongst office employees. Executives saw a stronger transformation of their job content, so that they progressively caught up connected employees in terms of teleworking feasibility. Just before Covid-19, 60 % of executives and 70 % of connected employees could work from home. During the Covid-19 crisis, the increase in tasks that make teleworking feasible was actually observed only for executives who eventually became the most teleworkable occupation with almost 85 % of jobs that could be teleworked. This also means that much of the factors that would make teleworking possible for connected employees have remained stable throughout the Covid 19 crisis. Teleworking feasibility finally remained low—slightly above 10 %—for "non-connected' employees over the studied period and only increased slightly.

These differences across occupations appear to be driven mostly by the use of connected computers and the fact to have at least some physically demanding tasks to perform (Figure A2). The share of hours spent on a connected computer has been historically much larger for connected employees. In this group, 60 % of hours worked were already spent using computers in 1996, in comparison to only 30 % of hours worked among executives and 15 % among non-connected employees. Executives saw the largest transformation of their job content with a doubling from 35 to 70 % of their time spent in front of a computer between 1996 and 2019. This is the main feature explaining that teleworking feasibility increased more for them than for the other groups. Indeed, the share of jobs requiring contacts with the public is comparable and stable over time before the Covid-19 crisis in all three groups, ranging between 60 % and 75 %.[5] Regarding physically demanding jobs, there is a huge gap between non-connected employees and the other two occupational

[5]We nevertheless note that during the Covid-19 crisis, it falls much less for non-connected employees, showing that it was harder to adapt working conditions in this group.

groups. Less than 20 % of non-connected employees have a job that is not at all physically demanding, while this is the case for around 60 % of connected employees and executives. These proportions are stable over time.

Panel (b) of Figure 4 shows that, even if teleworking has been more feasible for connected employees than for executives, working from home during regular hours has always been much more developed for executives since 2003.[6] The ratio between WFH and teleworking feasibility is only around 10 % for connected employees before the Covid-19 crisis, while it is three times larger among executives (panel (c)). It is actually largest among non-connected employees but as feasibility remains low in this group, the ratio should be interpreted with more caution—to put it differently, the ratio is large but the gap in percentage point between WFH and feasibility remains small. In all three groups, the ratio strongly increased during the Covid-19 crisis. In relative terms, the most striking increase is that of connected employees, whose ratio increases 5 fold over a two-year period. This again suggests that WFH was particularly under-used compared to its feasibility among connected employees before the Covid-19 crisis.

4.3 Organizational barriers to WFH

Why is the recourse to teleworking or WFH so far away from its feasibility? And why are there such large differences in the use of teleworking across occupations given its feasibility? In this section, we provide some evidence on the supply and demand side factors that may have played a role, namely workers' desire to WFH (i.e. to supply work done from home) and management practices that could be related to firms' demand for WFH.

[6] Only aggregated statistics on teleworking are available for earlier years. This is why we use the LFS and focus on working from home during regular hours (rather than teleworking) that we can observe since 2003.

Workers' desire to telework by occupation. We first show simple statistics on workers' desire to telework directly observed in the Tracov survey in early 2021. Figure 5 shows, for each occupation category, how workers that can work from home are split according to their desire to work from home. There are four subgroups: workers that telework and wanted to do so, workers that telework but did not want to do so, workers that do not telework and are happy not to, and workers that do not work from home but would like to do so. One needs to keep in mind that those statistics are provided in a period where teleworking has just increased sharply, and the gap between teleworking and its feasibility (the two last groups) has been strongly reduced compared to the pre-Covid-19 period. Even in this context, most of the gap between teleworking and its feasibility is composed of workers who would like to telework. For example, 17.6 % of executives who could telework do not do so, and slightly more than half of them (8.9 %) would like to telework. In addition, in all groups, the share of teleworkers who would prefer not teleworking is lower than the share of non-teleworkers who could telework and would like to do so. This means that if teleworking were perfectly aligned on workers' preferences in 2021, it would increase further, showing that the remaing wedge between teleworking and its feasibility still observed in 2021 cannot be explained by supply side factors. Even if the Covid-19 crisis may have boosted workers' desire to telework for health-related reasons, we think that this conclusion is likely to hold as well prior to the Covid-19 crisis. This is because much fewer workers were teleworking before the pandemic and only a few of the many workers that were pushed to telework during the Covid-19 crisis declare they would prefer not to telework.

The other takeaway from Figure 5 is that supply-side factors cannot explain differences in teleworking across skill groups. Indeed, the share of workers that can telework but do not and would like to do so is largest among connected employees, while the share of workers that telework but would prefer not to is largest among executives. If teleworking

was fully aligned on workers' preferences (among workers that can telework), the share of teleworkers would increase from 7 to 10 % among non-connected employees, from 49 to 58 % among connected employees, and from 65 to 68 % among executives. Hence, if anything, workers' desires to teleworking, if taken into account, would decrease differences across skill groups.

Subordination, control and WFH. We focus on two main dimensions of the collective organization of work that might influence firms' willingness to allow their employees to work from home: the degree of autonomy and the extent of hierarchical control at work. These variables are natural candidates because they differ widely between low- and high-skilled workers and are likely to be related to managers' willingness to let their subordinates WFH. Indeed, WFH implies a more remote and difficult control of workers' effort at work. In settings where workers are closely monitored (e.g. because the management worries about shirking), managers may be more reluctant to allow them to WFH as this would mean a partial loss of their ability to control them.[7]

We first test this simple theory during the Covid-19 crisis in 2021 using a series of linear regressions of the following type:

$$T_{ij} = \alpha Feas_{ij} + \beta Occ_i + \gamma Feas_{ij} * Occ_i + \delta X_{ij} + \delta' X'_{ij} + \epsilon_{ij}$$

where T_{ij} is an indicator variable equal to 1 if worker i in firm j telework at least half a day per week, $Feas_{ij}$ an indicator variable equals to 1 if worker i indicates that her job is feasible from home, Occ_i two occupation indicators for "connected employees" and executives, X_{ij} a set of variables describing either worker i's desire to work from home or her degree of autonomy and control in her job, and X'_{ij} additional controls for workers'

[7] In some jobs, such as call centers (Bloom et al., 2015), individual productivity can be directly monitored and this argument does not apply.

demographics and their firms' size and industry.

α captures the link between teleworking and teleworking feasibility and β the gaps in teleworking between the three occupational groups conditional on teleworking feasibility. γ captures differences in the link between teleworking and its feasibility across occupations. δ capture the relationship between supply and demand factors and teleworking. We examine as well if controlling for these factors narrows the gaps between occupations conditional on feasibility.

Table 2, column (1) confirms that there is a strong link between teleworking feasibility and actual teleworking: jobs that can be teleworked are 63.8 % more likely to be indeed teleworked. It also confirms that there are large gaps across occupations in teleworking conditional on its feasibility: executives and connected employees are respectively 15 and 6 percentage points more likely to telework than are no-connected employees for a job that are similarly feasible. Having a job feasible from home also increases the recourse to teleworking more for executives and connected employees than for non-connected employees (column 2). The gaps between executives and connected employees are also always large and statistically significant. These differences (both in the average recourse to teleworking and the link between feasibility and teleworking) across broad occupational groups are only slightly reduced when detailed controls for workers' demographics are added (column 3). Consistent with the conclusions of the previous section, controlling further for workers' desire to work from home leaves the gaps across occupations largely unaffected (column 4). In column (5), we include individual-level measures of the degree of hierarchical control (a dummy for having at least some control and a categorical variable from very light to very intensive control) and autonomy at work (also categorical). Both categorical variables have been standardized to have mean 0 and a standard deviation of 1. Autonomy is positively associated with a higher likelihood of having at least half a day of teleworking. The relationship between hierarchical control and teleworking goes in the opposite direction,

as expected. However, these associations remain quantitatively small (a one standard deviation in any of these variable is associated with variations in teleworking lower than 2 percentage points). Hence, these factors have little incidence on the gaps in teleworking across occupation during the Covid-19 crisis. Column (6), which controls both for supply and demand factors on top of workers' demographics confirms that large gaps across occupations in the recourse to teleworking remained during the Covid-19 crisis, and that they cannot be easily explained by workers' desire to telework, or by managerial practices.

Can these conclusions be extended to the pre-Covid period? To study this point, we estimate similar regression models using the 2019 working conditions survey. Teleworking feasibility is not observed directly, and we therefore replace it by its prediction, so that differences across occupations are conditional on predicted feasibility.[8] Column (1) of Table 3 shows that conditional on predicted feasibility, there are also in 2019 large gaps in the prevalence of teleworking across broad occupational groups: executives (connected employees) are 24 (6) percentage points more likely to telework than are non-connected employees (who barely telework in 2019). Having a job that is predicted to be feasible remotely also increases more the likelihood of working from home for executives and non-connected employees than it does for connected employees (column 2). These differences across occupations (and in particular the large gap between connected employees and executives) is largely robust to controlling for basic workers' demographic characteristics (column 3) and management practices (column 4).

[8]To suggest that this change has no incidence on the conclusions, we replicate the analysis in 2021 after also replacing teleworking feasibility by its prediction (see Table A3 to be compared to Table 2). The gaps across occupations conditional on predicted feasibility are larger than those conditional on actual feasibility, but the influence of demand-side factors on these gaps remains close to 0. Not surprising, the link of teleworking with predicted feasibility is also lower than its link with actual feasibility. However the differences in this link across occupations are comparable in both specifications. The only variable that has a significant influence on the gaps across occupations in the replication exercise is workers' desire to telework. This is partly mechanical, as this variable is mechanically correlated with actual feasibility (it is observed only for jobs that are feasible from home and we impute it to be 0 for jobs that cannot be done) and its estimated effect in regressions that do not also control for actual feasibility cannot be easily interpreted.

We take advantage of the richness of the 2019 working condition survey to control more extensively for workers' autonomy and hierarchial control, and also add controls for having many interruptions at work, or having deadlines. All these variables affect teleworking beyond feasibility constraints. Some have a strong influence: facing no deadline in her daily work is associated with a 4 percentage points lower probability to telework, while having no hierarchy is associated with a 6 percentage point larger probability to telework. Given that less than 10 % of the workforce telework in 2019, these magnitudes are very large, clearly showing that the organisational aspects of work and management practices were strongly related to the probability of teleworking before the Covid-19 crisis. The estimated coefficient for predicted feasibility is indeed around 0.05 in Table 3, which is much smaller than in 2021 (see Table A3) and comparable in magnitude the estimated associations between teleworking and the absence of hierarchy.

Workers' education and firm size are observed in the 2019 working condition survey while they are not in Tracov. Their inclusion as controls actually reduces by 4 percentage points the premium of executives in terms of teleworking (column 5). This reduction is driven by the control for education, revealing that workers' background, even for jobs that are similar in many other dimensions, may also influence their probability to work from home.

A potential concern with the results above is that our ability to predict teleworking precisely for a given worker might be poor.[9] To alleviate this concern, we directly add as controls in column (6) of Table 3 the 67 task variables used to predict teleworking in 2019. When we do this, differences across occupations are reduced but only slightly. They remain quantitatively very large given the average level of teleworking in 2019. The relationships between the presence of a hierarchy or deadlines and teleworking also remain large and largely unaffected.

[9]Note that this criticism does not apply to our historical time series in which we were considering averages in predicted feasibility over large groups of workers.

Two broad conclusions emerge from the analyses above. First, management practices are related to teleworking beyond feasibility constraints. Their relation to teleworking used to be very large quantitatively in 2019 and became second order in 2021, when teleworking was much more determined by feasibility constraints. Second, there are very large differences in the prevalence of teleworking between high-skilled and low-skilled occupations, even when comparing occupations and jobs that can be done from home to the same extent. These differences do not seem to be explained by feasibility constraints. They are also largely unexplained by management practices that directly relate to teleworking and differ widely across occupations. The gaps across occupations therefore represent a puzzling pattern around the development of working from home. They deserve further research, all the more that they induce large inequalities across skill and income groups in the access to the opportunity to work from home.

5 Conclusion

Teleworking and working from home practices have increased over the past thirty years in two phases. The first phase saw a gradual increase from the early nineties to the brink of the Covid-19 crisis. Over this period, work practices that are today the strongest determinants of telework feasibility, in particular the share of their total working time that workers spend using ICT and computers, have increased continuously. If only for these factors, one would have expected teleworking to increase much earlier, especially for employees, who already spent more than half of their working time on ICT tools by the late nineties. Conversely, executives and managers saw their work practices fundamentally change, and to some extent in the 2010s, their teleworking habits too.

During the Covid 19 crisis, telework practices increased dramatically for the workers that could telework. For executives, this meant that teleworking actually came much closer

to its full potential and desired level, all while actual work practices evolved substantially. For connected employees, a larger gap remains between telework practices and their desired level; and the technical "teleworkability" was actually much less affected.

This discrepancy between employees and executives is very robust statistically. Some of it can be explained by organisational factors, such as autonomy or monitoring. A larger share of it remains unexplained by individual characteristics, even when mobilizing very detailed data on work practices, which begs for further research.

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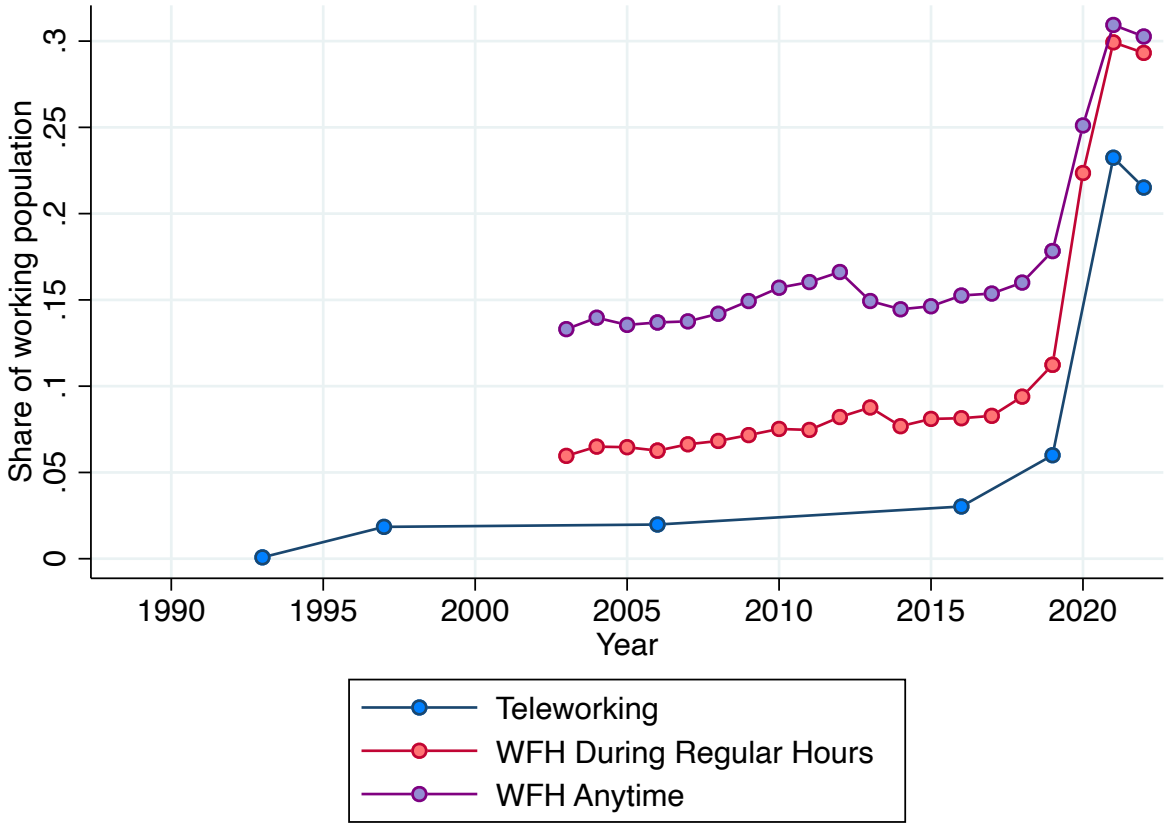
Figures and Tables

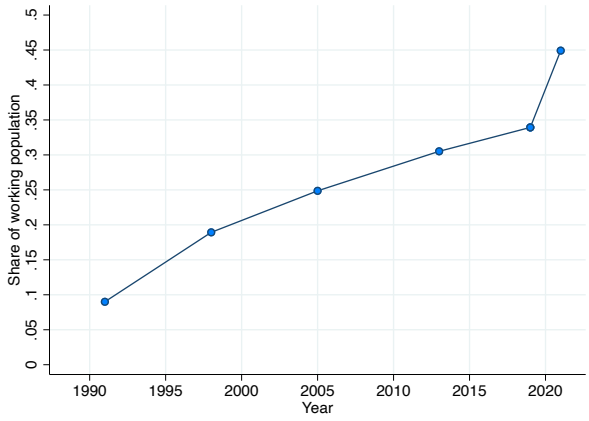
Figure 1: Evolution of teleworking and working from home since 1993



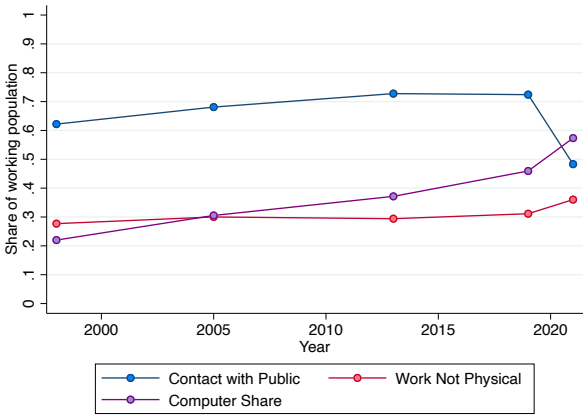
Source: Teleworking is obtained from various sources described in Section 2.2. WFH is measured using the Labor Force Surveys.

Figure 2: Evolution of predicted teleworking feasibility and tasks making teleworking feasible since 1991

a) Predicted teleworking feasibility



b) Evolution of tasks making teleworking feasible

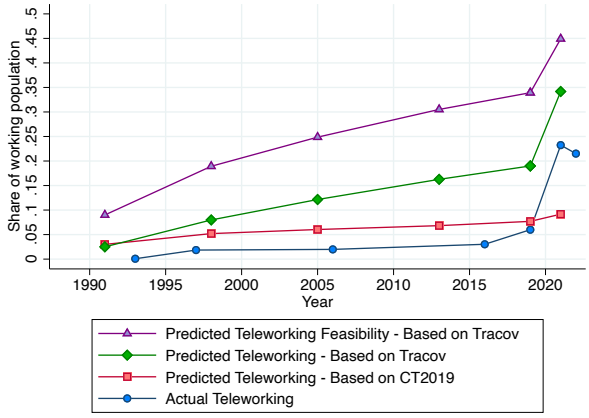


Source: Working Condition surveys 1991 to 2019. Tracov survey 2021.

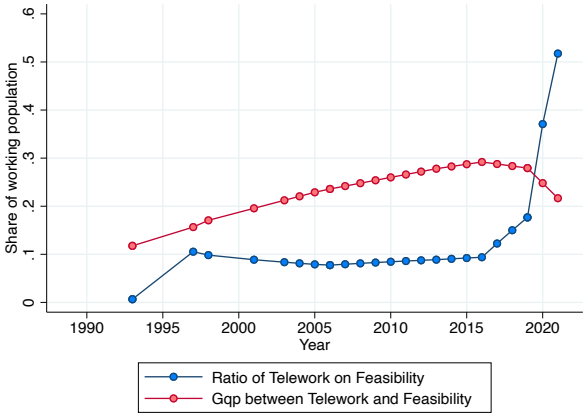
Note: Random forests are used to predict teleworking feasibility based on job tasks in early 2021. Before 2021, teleworking feasibility is no longer directly observed. In panel a), we use the same observed tasks as in 2021 in earlier years to predict the extent of ML feasibility in the labor market the corresponding year. In panel b), we show the evolution of the tasks that predict teleworking feasibility the most.

Figure 3: Gaps between teleworking and teleworking feasibility since 1991

a) Actual teleworking, teleworking predicted in 2019 and teleworking feasibility



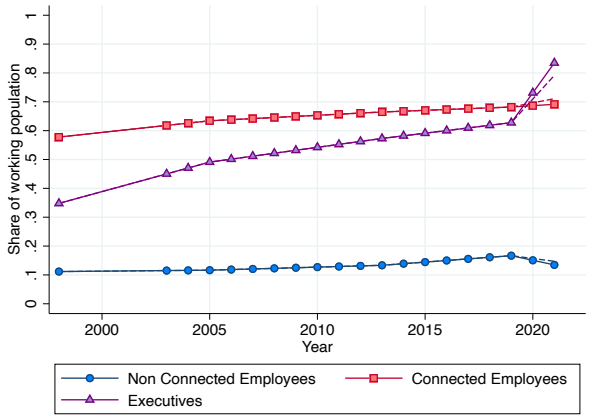
b) Ratio between teleworking and predicted teleworking or teleworking feasibility



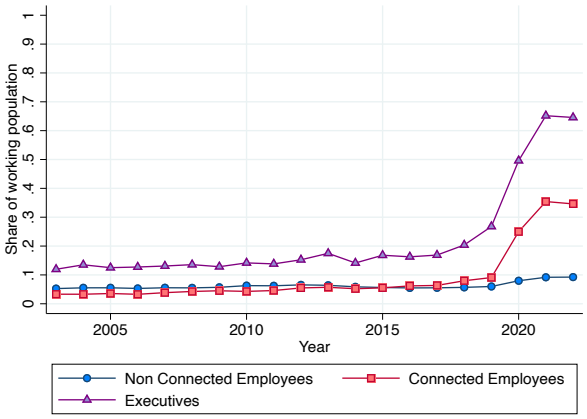
Source: Working Condition surveys 1991 to 2021 for teleworking feasibility. Archive data for teleworking.

Figure 4: Evolution of working from home and teleworking feasibility by occupation

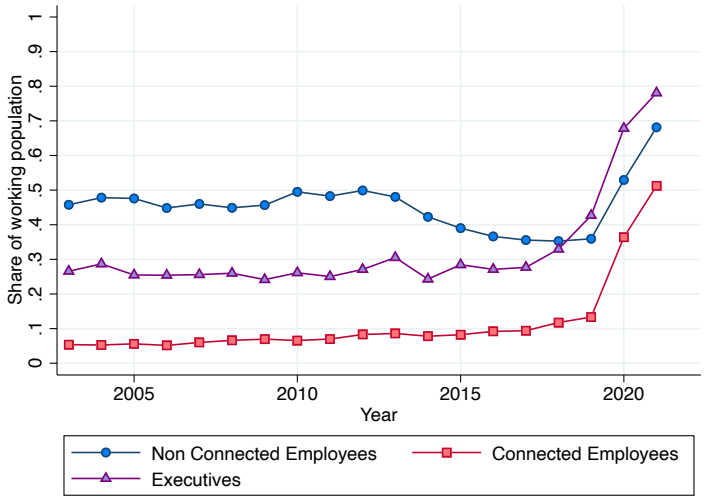
a) Teleworking feasibility



b) Working from home (during regular hours)



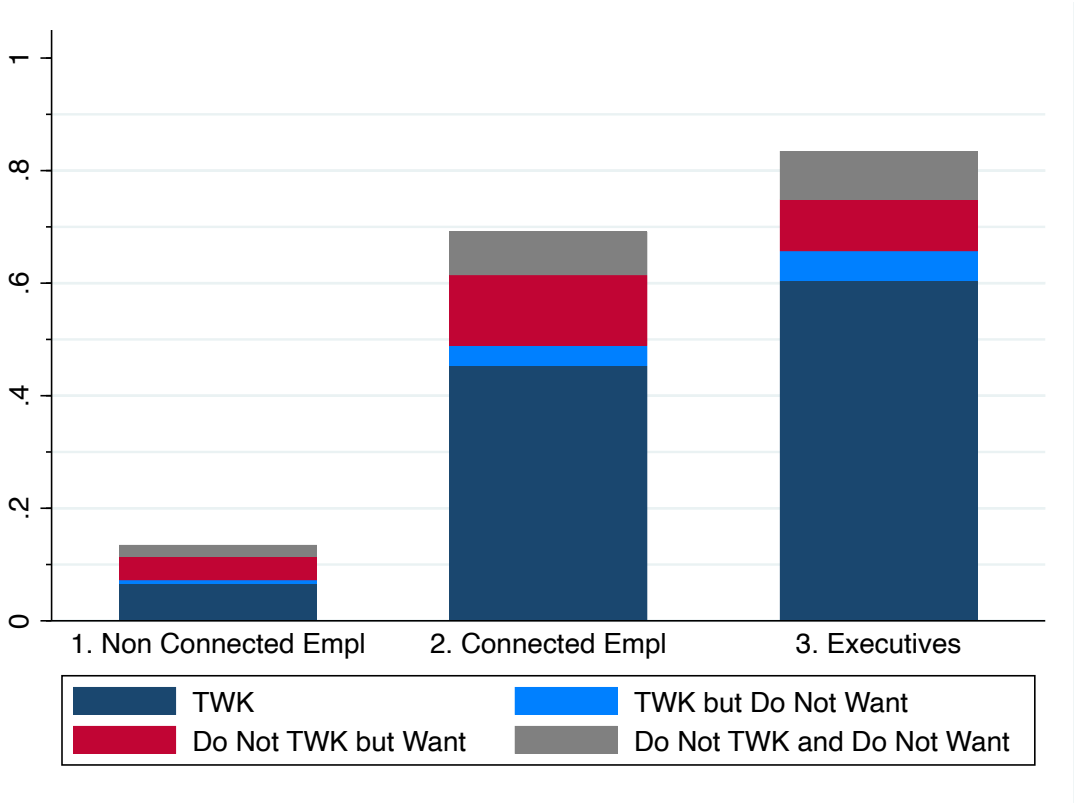
c) Ratios between working from home and teleworking feasibility



Source: Working Condition surveys 1991 to 2021. Labor force survey surveys.

Note: The Figure shows...

Figure 5: Mismatch between working from home and desired working from home by occupation



Source: Tracov 2021.

Table 1: Random Forest Estimation Results

		First Best, Full Model	Second Best, Restricted Model
Telework Feasibility 2021	Nb Var	13	5
	MSE	0.111	0.158
	Five most important var	Computer Share	Work always physical
		Work always physical	Computer Share
		Work often physical	Work often physical
		Contact with public/clients	Work sometimes physical
		Work sometimes physical	Public contact
Telework 2021	Nb Var	13	5
	MSE	0.142	0.183
	Five most important var	Computer Share	Work often physical
		Work always physical	Work always physical
		Work often physical	Computer Share
		Work close to other people	Public contact
		Contact with public/clients	Work sometimes physical
Telework 2019	Nb Var	67	5
	MSE	0.013	0.055
	Five most important var	Computer Share	Work always physical
		Does not work alone	Computer Share
		Work depends on external demand that does not require immediate response	Public contact
		Public contact	Work sometimes physical
		Reads small letters/numbers	Work often physical

Table 2: Regressions of Teleworking on Actual Feasibility and Occupation Groups in 2021

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent Variable: Teleworking Dummy					
TWK Feasible	0.638***	0.594***	0.576***	0.218***	0.574***	0.214***
	(0.00724)	(0.00882)	(0.00884)	(0.0117)	(0.00883)	(0.0116)
Executives	0.146***	0.135***	0.113***	0.110***	0.107***	0.104***
	(0.00914)	(0.0107)	(0.0107)	(0.0100)	(0.0107)	(0.00998)
Connected Employees	0.0609***	0.0849***	0.0752***	0.0717***	0.0689***	0.0650***
	(0.00755)	(0.00787)	(0.00783)	(0.00730)	(0.00784)	(0.00729)
TWK Feasible X Executives		0.206***	0.186***	0.177***	0.179***	0.169***
		(0.0210)	(0.0209)	(0.0195)	(0.0209)	(0.0194)
TWK Feasible X Connected Employees		0.125***	0.116***	0.106***	0.115***	0.104***
		(0.0161)	(0.0160)	(0.0149)	(0.0159)	(0.0148)
Wants to TWK				0.444***		0.446***
				(0.0103)		(0.0102)
No Hierarchy					-0.0104	-0.0106
					(0.0115)	(0.0107)
Degree of Hierarchy Control					-0.0115***	-0.0125***
					(0.00379)	(0.00352)
Autonomy					0.0271***	0.0288***
					(0.00291)	(0.00271)
Observations	12,342	12,342	12,342	12,342	12,296	12,296
R-squared	0.562	0.566	0.583	0.638	0.587	0.643
Demographic Controls			Yes	Yes	Yes	Yes

Note: Demographic controls include gender, age, seniority, continent of Birth, region of living. Firm size controls are a second order polynomial in the number of employees. Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

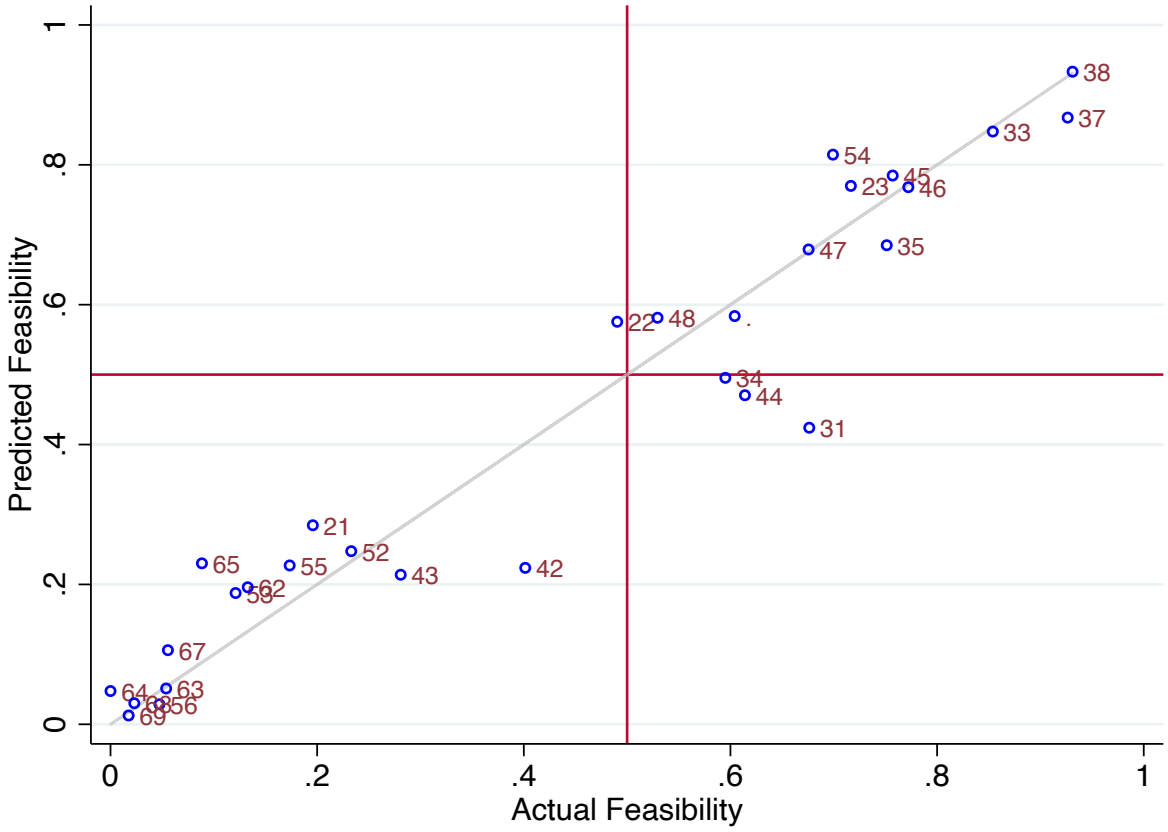
Table 3: Regressions of Teleworking on Predicted Feasibility and Occupation Groups in 2019

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent Variable: Teleworking Dummy					
TWK Feasiblility Prediction	0.0491***	0.0523***	0.0509***	0.0415***	0.0212***	-0.0163*
	(0.00499)	(0.00531)	(0.00533)	(0.00549)	(0.00581)	(0.00866)
Executives	0.243***	0.230***	0.220***	0.199***	0.156***	0.132***
	(0.00584)	(0.00649)	(0.00658)	(0.00686)	(0.00809)	(0.00851)
Connected Employees	0.0595***	0.0838***	0.0798***	0.0704***	0.0612***	0.0408***
	(0.00600)	(0.00681)	(0.00682)	(0.00688)	(0.00719)	(0.00761)
TWK Feasible Pred × Executives		0.0147	0.00445	0.00437	0.0148	0.0379***
		(0.0120)	(0.0120)	(0.0121)	(0.0123)	(0.0128)
TWK Feasible Pred × Connected Employees		-0.0814***	-0.0782***	-0.0764***	-0.0743***	-0.0523***
		(0.0124)	(0.0124)	(0.0125)	(0.0125)	(0.0130)
Autonomy in Deadlines				0.00514	-0.000637	-0.00432
				(0.00479)	(0.00479)	(0.00488)
No Deadlines				-0.0410***	-0.0377***	-0.0373***
				(0.00593)	(0.00603)	(0.00626)
Surveiled by Hierarchy				-0.0202***	-0.0117**	-0.00836*
				(0.00468)	(0.00470)	(0.00492)
Can Interrupt Work				0.0178***	0.0140***	0.00661
				(0.00503)	(0.00518)	(0.00536)
No orders				0.000422	0.00423	0.00588
				(0.00975)	(0.00977)	(0.0100)
No Hierarchy				0.0574***	0.0733***	0.0672***
				(0.0105)	(0.0124)	(0.0127)
Autonomy regarding orders				0.0136***	0.00972**	0.00678*
				(0.00389)	(0.00390)	(0.00401)
Autonomy regarding workload				0.000350	0.000131	-9.60e-05
				(0.00211)	(0.00214)	(0.00219)
Works autonomously				0.00791***	0.00965***	0.00575***
				(0.00207)	(0.00210)	(0.00217)
Degree of supervision of other				0.00651***	0.00691***	0.00594**
				(0.00225)	(0.00226)	(0.00236)
Observations	17,709	17,709	17,656	17,468	17,070	16,578
R-squared	0.134	0.137	0.149	0.160	0.209	0.224
Demographic Controls			Yes	Yes	Yes	Yes
Dimploma FE					Yes	Yes
Industry FE					Yes	Yes
Firm Size Controls					Yes	Yes
Complete Task Variables						Yes

Note: Demographic controls include gender, age, seniority, continent of Birth, region of living. Firm size controls are a second order polynomial in the number of employees. Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Appendix

Figure A1: Predicted and actual teleworking feasibility for each 2-digit occupation

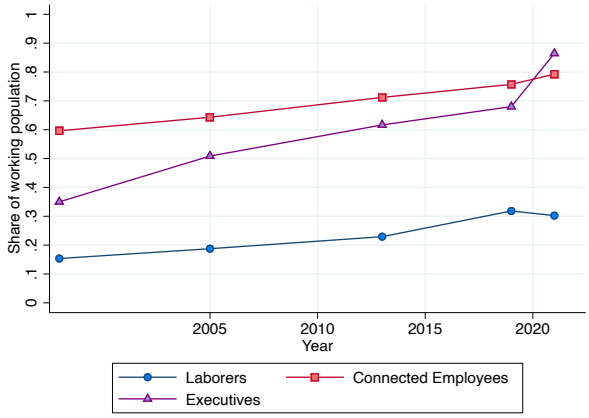


Source: Tracov 2021.

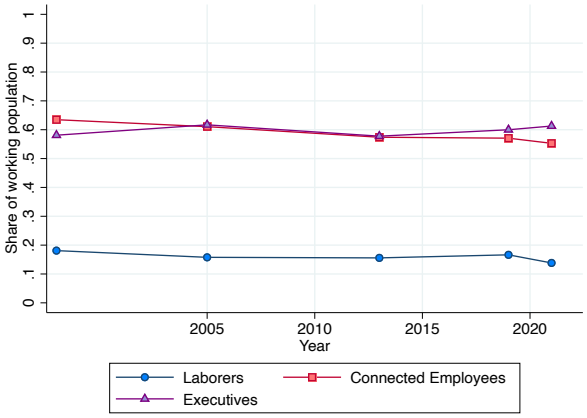
Note:

Figure A2: Evolution of tasks that make teleworking feasible by occupation

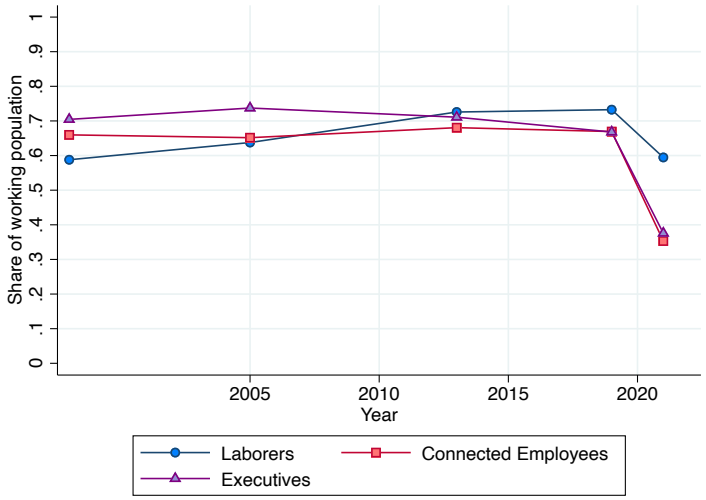
a) Share of hours spent using connected computers



b) Share of not physically demanding jobs



c) Share of jobs requiring contacts with the public



Source: Working Condition surveys 1991 to 2021.

Table A1: Questions of the Working Conditions survey

Question	Working conditions survey 1991	1998	2005	2013	2019	Tracov 2021
Intensity of ICT use at work						
Au cours de votre travail, utilisez-vous (même occasionnellement) a)... un ordinateur fixe ?				✓	✓	
Au cours de votre travail, utilisez-vous (même occasionnellement) a)... un micro-ordinateur relié à un réseau ou à d'autres ordinateurs ?		✓	✓			
Au cours de votre travail, utilisez-vous (même occasionnellement) a)... un micro-ordinateur non relié ?		✓	✓			
Au cours de votre travail, utilisez-vous (même occasionnellement) b)... un ordinateur portable ? *b) ...un micro-ordinateur portable* (2005)		✓	✓	✓	✓	
Au cours de votre travail, utilisez-vous (même occasionnellement) c)... une tablette, un PDA, un terminal mobile ou embarqué ? *c)... un terminal ou une console informatique* (1998, 2005)		✓	✓		✓	
Disposez-vous d'une boîte à lettres électronique professionnelle ?			✓	✓	✓	
En dehors de la messagerie, utilisez-vous Internet à des fins professionnelles ?		✓	✓	✓	✓	
Utilisez-vous un Intranet ou un réseau de communication interne ?			✓	✓	✓	
Quand vous n'êtes pas sur votre lieu de travail, pouvez-vous accéder... b)... au système informatique de votre établissement ou organisation ?				✓	✓	
Au total, pendant combien de temps utilisez-vous à titre professionnel les matériels informatiques dont nous venons de parler ?	✓	✓	✓	✓	✓	✓
Intensity of face-to-face interactions with either colleagues or the public						
...interactions with the public						
Etes-vous en contact direct avec le public ? (usagers, patients, élèves, voyageurs, clients, fournisseurs, etc)	✓	✓	✓	✓	✓	✓

... de vive voix en face à face ?			✓	✓	✓	
... par téléphone ?			✓	✓	✓	
... par voie électronique (mail, forum, chat, réseaux sociaux) ?			✓	✓	✓	
Votre rythme de travail vous est-il imposé par une demande extérieure (clients, patients, public) obligeant à une réponse immédiate ?	✓	✓	✓	✓	✓	
Vivez-vous des situations de tension dans vos rapports avec le public (usagers, patients, élèves, voyageurs, clients, fournisseurs, etc.) ?	✓	✓	✓	✓	✓	
...interactions with colleagues						
Travaillez-vous seul ?				✓	✓	✓
Votre rythme de travail vous est-il imposé par la dépendance immédiate vis-à-vis du travail d'un ou plusieurs collègues ?	✓	✓	✓	✓	✓	
Vivez-vous des situations de tension c) ... dans vos rapports avec vos collègues ? 3. (pas de collègues)	✓	✓	✓	✓	✓	
Votre rythme de travail vous est-il imposé les contrôles ou surveillances permanents (ou au moins quotidiens) exercés par la hiérarchie ?	✓	✓	✓	✓	✓	
Measures of physical intensity and manual work						
L'exécution de votre travail vous impose-t-elle ...						
... de rester longtemps debout ?	✓	✓	✓	✓	✓	
... de rester longtemps dans une autre posture pénible ou fatigante à la longue ?	✓	✓	✓	✓	✓	
... d'effectuer des déplacements à pieds longs et fréquents ?	✓	✓	✓	✓	✓	
... de porter ou déplacer des charges lourdes ?	✓	✓	✓	✓	✓	
... d'effectuer d'autres efforts physiques importants ?	✓	✓				
... d'effectuer des mouvements douloureux ou fatigants ?		✓	✓	✓	✓	
... de subir des secousses ou vibrations ?	✓	✓	✓	✓	✓	
... de ne pas quitter votre travail des yeux ?	✓	✓	✓	✓	✓	
... de lire des lettres ou des chiffres de petites tailles,						

mal imprimés, mal écrits ?	✓	✓	✓	✓	✓
... d'examiner des objets très petits, des détails fins ?	✓	✓	✓	✓	✓
... de faire attention à des signaux visuels ou sonores brefs, imprévisibles ou difficiles à détecter?	✓	✓	✓	✓	✓
... de porter des vêtements de travail ?	✓				
Quand vous travaillez, si une personne, placée à 2 ou 3 mètres de vous, vous adresse la parole ... 1. vous l'entendez, si elle parle normalement 2. vous l'entendez, à condition qu'elle élève la voix 3. vous ne pouvez pas l'entendre	✓	✓	✓	✓	✓
Votre rythme de travail vous est-il imposé par ... a) ... le déplacement automatique d'un produit ou d'une pièce ?	✓	✓	✓	✓	✓
Votre rythme de travail vous est-il imposé par ... b) ... la cadence automatique d'une machine ?	✓	✓	✓	✓	✓
Où passez-vous la plus grande partie de votre temps de travail ? 5. En déplacement (ex : hôtesse de l'air, VRP, chauffeur routier, conducteur...)				✓	✓
8. Sur un ou plusieurs chantiers				✓	✓
Est ce principalement parce que ... ? 3 - vous êtes en mission, vous travaillez sur un chantier, ou vous intervenez chezs des clients			✓		
Utilisez-vous un véhicule dans le cadre de votre travail ou pour vos besoins professionnels, en dehors des trajets domicile-travail ?				x ✓	✓

Health and Safety

A votre emplacement de travail, êtes-vous amené à ...

a) ... respirer des fumées ou des poussières ?	✓	✓	✓	✓	✓
b) ... être en contact avec des produits dangereux ?	✓	✓	✓	✓	✓
c) ... être exposé à des risques infectieux ?	✓	✓	✓	✓	✓
d) ... risquer d'être blessé ou accidenté ?	✓	✓	✓	✓	✓
e) ... risquer des accidents de la circulation au cours du travail ?	✓	✓	✓	✓	✓

Votre employeur met-il à votre disposition des équipements individuels de protection comme des gants, des lunettes, des chaussures de sécurité, un harnais, ... ?	✓	✓
Les utilisez-vous ?	✓	✓
Quality of internet connection at home		
Commune de résidence		✓

Table A2: Comparison of O*NET Questions Used by DN 2020 with Questions from 2019 Working Conditions Survey and 2021 Tracov Survey

O*NET Question (DN 2020)	2019 Working conditions Survey	2021 Tracov Survey
GWA23: Repairing and Maintaining Electronic Equipment	-	
WC14: Deal with violent people weekly	TENSION1: vivez vous des situations de tension dans vos rapports avec le public (usagers, patients, élèves, voyageurs, clients, fournisseurs, etc.) ?	
GWA22: Repairing and Maintaining Mechanical Equipment		
WC33: Exposed to minor burns, cuts, bites, or stings weekly	SECACCID: A votre emplacement de travail, êtes-vous amené à ... d) ... risquer d'être blessé ou accidenté ?	
WC17/18: Majority of respondents say outdoors every day	CWDEPLA: Effectuer des déplacements à pied longs ou fréquents - LIEUW==8: passe la plus grande partie du temps de travail sur un ou plusieurs chantiers	

GWA18: Controlling Machines and Processes		
GWA20: Operating Vehicles, Mechanized Devices, or Equipment	RWDEP: rythme de travail imposé par le déplacement automatique d'un produit ou d'une pièce ? - RWCAD: rythme de travail imposé par la cadence automatique d'une machine ?	
WC29: Exposed to diseases or infection weekly		
GWA17: Handling and Moving Objects	CWLOURD: Porter des charges lourdes	d7: fréquence du travail physiquement exigeant
GWA16: Performing General Physical Activities	CWDEBOUT: Rester longtemps debout - CWPOSTU: Rester longtemps dans une posture pénible - CWLOURD: Porter des charges lourdes - CWMVVT: Effectuer des mouvements douloureux ou fatigants - CWVIB: Subir des secousses ou vibrations	d7: fréquence du travail physiquement exigeant
GWA4: Inspecting Equipment, Structures, or Materials	CWMINUS: Examiner des objets très petits	
WC4: Use email less than once per month	MEL: Disposez-vous d'une boite à lettres électronique professionnelle ?	d11==1: 0 heure par jour d'utilisation des équipements numériques
GWA32: Performing for or Working Directly with the Public	TRAVSEUL: Travaillez-vous seul ? - TENSION3 modalité 3: pas de collègue - PUBLIC1: Êtes-vous en contact direct avec le public de vive voix en face à face	d6_2: Vous trouvez-vous régulièrement à proximité physique du public, clients, patients

WC37: Majority of time walking or running	CWDEPLA: Effectuer des déplacements à pied longs ou fréquents
WC43/44: Majority of time wearing protective or safety equipment	EPI: Votre employeur met-il à votre disposition des équipements individuels de protection comme des gants, des lunettes, des chaussures de sécurité, un harnais, ... ? - EPIUTIL Les utilisez-vous ?

Table A3: Regressions of Teleworking on Predicted Feasibility and Occupation Groups in 2021

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent Variable: Teleworking Dummy					
TWK Feasiblility Prediction	0.421***	0.386***	0.366***	0.119***	0.361***	0.112***
	(0.00810)	(0.00958)	(0.00950)	(0.00835)	(0.00954)	(0.00836)
Executives	0.325***	0.283***	0.249***	0.0954***	0.246***	0.0926***
	(0.0102)	(0.0128)	(0.0127)	(0.0105)	(0.0127)	(0.0105)
Connected Employees	0.185***	0.188***	0.173***	0.0569***	0.169***	0.0527***
	(0.00863)	(0.00916)	(0.00907)	(0.00753)	(0.00910)	(0.00754)
TWK Feasible × Pred Executives		0.185***	0.169***	0.153***	0.162***	0.143***
		(0.0224)	(0.0222)	(0.0181)	(0.0222)	(0.0180)
TWK Feasible Pred × Connected Employees		0.0987***	0.0892***	0.0775***	0.0862***	0.0744***
		(0.0181)	(0.0178)	(0.0145)	(0.0178)	(0.0145)
Wants to TWK				0.570***		0.572***
				(0.00723)		(0.00722)
No Hierarchy					-0.0313**	-0.0124
					(0.0133)	(0.0108)
Degree of Hierarchy Control					-0.00811*	-0.0112***
					(0.00437)	(0.00355)
Autonomy					0.0236***	0.0268***
					(0.00336)	(0.00273)
Observations	12,364	12,364	12,364	12,364	12,313	12,313
R-squared	0.414	0.417	0.447	0.633	0.450	0.637
Demographic Controls			Yes	Yes	Yes	Yes

Note: Demographic controls include gender, age, seniority, continent of Birth, region of living. Firm size controls are a second order polynomial in the number of employees. Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1