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The new industrial revolution: the optimal choice for flexible work companies

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ooo This draft: 27 April 2022 ooo

Abstract

The forced remote working relationships experienced during the COVID-19 pandemics made employers and employees more aware of the productivity gains arising from the digital revolution. To investigate the characteristics of such gains, we model firms' production allowing companies to choose among three types of (face-to-face in presence, remote synchronous, and remote asynchronous) employees relationships. The introduction of remote interactions allows us to outline five features affecting workers productivity such as i) mobility reduction, ii) frequency of interactions, iii) optimal time/place, iv) work-life balance, and v) relationship decay effects. We calculate the optimal share of the three types of relationships that maximise corporate profits conditional to reasonable parametric assumptions on the five effects under perfect and asymmetric information. We as well assess the potential productivity growth of companies that use only face-to-face interactions when allowing also remote interactions. We finally discuss existing private business contracts that introduced hybrid combinations of in-person and remote work activities for their employees, that are aligned with our theoretical findings and call for new industrial and environmental policies at national and supranational level.

Keywords: flexible work, remote work, digital relationship, productivity.

JEL numbers: J24, O30.

1.Introduction

Flexible and remote work (teleworking) activities facilitated by digital technological advancements occurred well before COVID-19. The pandemics, however, has been a tremendous global shock and the associated lockdown policies moved the majority of workers worldwide to working from home. In other words, the unexpected lockdown measures served as an experiment for firms in many different industries to discover potential benefits associated to remote and flexible work, like productivity gains, better work-life balance, lower health risks, and less commuting emissions. This is why investigating the effects of this new industrial revolution on corporate productivity represents an ongoing challenge for researchers, companies, and policymakers. Our article aims to originally contribute to this field of research with a theoretical framework that assesses different characteristics of online and onsite work and simulates firms' choices in light of the digital revolution of flexible work.

In 2020, more than one in three workers started teleworking in Europe, and this number was higher for countries that suffered more from COVID-19 and with a well-developed teleworking system (ILO, 2021). More interestingly, approximately one in four workers with no previous experience of work

from home started teleworking (ILO, 2021). In the US, the impact might have been even larger: on average, workers moved their remote working time from 5 percent before 2020 to 60 percent in spring 2020 (Barrero et al., 2021).

However, not every job can be performed in a remote or flexible environment, and there is wide heterogeneity of prevalence of telework across different sectors. In Europe, the highest share of workers (40 percent or more) that use regularly or occasionally telework is among teaching professionals, information and communication technology professionals, and administrative and commercial managers. Obviously, for some workers like clerks and sales workers is almost impossible to move away from face-to-face interactions, and the share of workers involved in teleworking among these categories falls down to around 6 percent (Milasi et al., 2020).

Stimulated by the lockdown policies, many private companies have offered their employees hybrid contracts where they can mix between in office and telework activities (Table A1 in Appendix). Some of these firms may move back to pre-pandemic work conditions after the restrictions are eased, though. To make this choice and maximise their profits, many firms are currently trying to understand how hybrid contracts may impact on costs, employees' productivity, and revenues.

The scholarly debate on the relationship among telework, corporate profits, and productivity is limited: it mostly deals with surveys and case studies and presents an insufficient number of robust rigorous theoretical and empirical approaches, especially after COVID-19. In relation to the existing literature, several surveys have shown that homeworking increases perceived productivity (Martin and MacDonnell, 2012; Bloom et al., 2015; Giovanis, 2018, Barrero et al., 2021; see also Kosteas et al., 2022, for a comprehensive review). In a randomised experiment on 249 call centre operators, Bloom et al. (2015) show that people working from home outperformed those working at the office by 13 percent, both in terms of hours spent logged onto the system and number of calls taken per minute. Moreover, follow-up interviews outline that this result was due to greater convenience of being at home, relative quietness of home environments, and higher levels of job satisfaction. More recently, similar results have been found also by Nakrošienė et al. (2019) and Gallardo and Withacre (2018). In both studies, the authors investigated the impact of teleworking on local economies and reported higher levels of worker satisfaction and productivity that in turn led to increased median income level. A deeper analysis shows that the effect of telework on productivity does not seem to be linear. Hoornweg et al. (2016) find that productivity may be higher when telework intensity is low. Felstead and Hanske (2017) show that remote working related benefits such as higher organisational commitment, job satisfaction, and job-related well-being come at the cost of higher inability to switch off.

As expected, during COVID-19 the interest of scholars for the effects of working from home increased, as mobility restrictions in 2020 made telework unexpectedly compulsory for many employees. Results of the literature related to this period are not unambiguous. Several studies find a significant and positive influence of work-life balance and job satisfaction on productivity (Saba et al. 2020; Ravi and Anulsksum 2021; Arkesteijn et al., 2021), mainly when working from home is facilitated by improved broadband connection and communication technologies (Kniffin et al., 2020). According to a survey from the GitLab (2020) conducted on 3000 professionals working remotely in the IT sector, more than half of the employees travel less and find themselves to be more productive and efficient.

On the contrary, a few studies documented a negative impact of working from home during the lockdown on productivity (Rubin et al., 2020; Gibbs et al., 2021). These changes in productivity may be due to the extraordinary conditions of the lockdown, when many firms were not well prepared to move all their tasks online and parents at work shared their home offices with children. In fact, higher communication and coordination costs, less intra- and inter-unit communications, and the

presence of children at home are all factors that contributed to increase worked hours and decrease productivity (Gibbs, 2021). Thus, these negative changes in productivity are likely to be associated with lockdown measures and not to occur in ordinary working conditions, where employers and employees have already paid the fixed costs for being well equipped.

Finally, some other analyses find no significant effects of telework on productivity, with similar proportions of employers reporting increased and decreased productivity (Boys, 2020; Russo et al. 2021).¹

The older and more recent empirical literature clearly documents the need of a theoretical framework to model firms' choices on remote and flexible working conditions. This would incorporate different factors affecting the nexus between teleworking and corporate productivity and allow to simulate and weight their effects on it.

Our paper aims to contribute to this literature with a theoretical model on firms' optimal choice of employers' interactions. Our analysis originally advances the scholarly debate in several respects. First, we identify three types of working relationships according to different hypotheses on time and space working constraints, and outline factors explaining their costs and productivity differences. Second, we compute the optimal shares of the three types of working relationships that minimise corporate costs and compare our results with currently adopted hybrid contracts. Third, we extend our model to the asymmetric information framework à la Shapiro and Stiglitz (1984) calculate wages that satisfy non-shirking constraint for remote work, and compare it with that for work at office.

In our model, firms minimise their costs in producing a given amount of output using workers' interactions as inputs. We as well take into account the effect of the digital revolution by assuming that workers have complementary non-overlapping skills, and they can meet in person (e.g., in-office meetings), remotely (e.g., phone or video calls), or they can interact remotely and sequentially (e.g., email conversations or shared documents). These three types of interactions, that act as inputs in the firm production function of our model, have different costs and productivities due to time and place constraints of in-person meetings, time constraints in remote simultaneous meetings and absence of both constraints in remote and sequential interactions.

We calibrate our model using five fundamental characteristics of remote work related to time and space constraints that affect costs and productivity: community time, frequency of interactions, time and place allocation, work-life balance, and quality of relationships.

A salient feature of our model is the redefinition of the standard microeconomic production function in terms of human relationships and interactions. In this sense we acknowledge that corporate productivity nowadays relies in most part on the performance of complex tasks requiring interactions, information exchange, and joint endeavour of several employees with complementary non-overlapping skills. As a consequence, isolated individual workers are not able to produce any output, and this is the case of our model. While labour and capital remain key ingredients for production, an in-depth analysis is urgently needed to investigate the role of workers' interactions. This is particularly important in a global context where international collaborations and digital infrastructures offer unique opportunities for firms.

Theoretical findings of our model show how the optimal shares of the three types of interactions change as assumptions on costs and productivity change. Overall, assuming remote interactions cost

¹ See also CIPD – Chartered Institute of Personnel and Development (2020a). Home working is set to more than double compared to pre-pandemic levels once crisis is over. CIPD Press Release, available at <https://www.cipd.co.uk/about/media/press/homeworking-increases> [accessed on 17 August 2020].

15 percent less and make workers 20 percent more productive, firms should have approximately 26 percent of in-person meetings, 32 percent of remote simultaneous meetings, and 41 percent of remote sequential interactions. Notably, this combination leads to almost 17 percent lower total costs and leave the total number of interactions constant.

The rest of the paper is organised as follows. Section 2 introduces the benchmark model. In section 3 we simulate different costs and productivity scenarios to see how the optimal number of cost minimizing interactions of the three types change. Section 4 extend the model to the asymmetric information case. In Section 5 we review the industry sectors that may be more suitable for our model. Section 6 discusses how corporate governances and policy-makers may benefit from our analysis, and the limitations they should consider as well. Section 7 concludes.

2 The benchmark model

We model firm activity as a function of workers' interactions using a Cobb-Douglas production function. We consider three possible types of interactions: i) *face-to-face synchronous* (F2F) interactions, requiring the same space and time allocation (that is, common place and simultaneous time constraints) for participants; ii) *remote synchronous* (RS) interactions, which require the same time allocation and a technology to hold a virtual meetings, but do not require participants being present at the same physical place (simultaneous time constraint only); iii) *remote asynchronous* (RA) interactions, which require a technology to communicate remotely and sequentially (e.g., email or messaging services) and therefore allow to remove both common place and simultaneous time constraints.

We assume that workers within a given firm have complementary, non-overlapping skills (e.g., different education degrees, different qualifications, etc.). Thus, workers cannot work without interactions as they need them to produce a positive output. This makes our companies far different from a Charlie Chaplin's "Modern Time" model, where production is generated by individual workers in assembly lines interacting with machines and hierarchically subordinated and controlled by a supervisor; differently, our firm is more akin to a company where production and productivity gains are created through interactions among workers with different, non-overlapping skills. We can therefore conveniently assume that, in absence of meetings, production for the second type of company is zero, while it is positive for the old, first type of company.

More formally, firms produce a given amount of quantity according to the following Cobb-Douglas production function:

$$Y = f(X_1, X_2, X_3) = a_0 X_1^{a_1} X_2^{a_2} X_3^{a_3}$$

where Y represents total output, X_1 , X_2 , and X_3 represent the number of F2F, RS, and RA interactions, respectively, a_0 is total factor productivity, and a_1 , a_2 , and a_3 are the output elasticities of the three types of interactions, respectively. To emphasise the dependency between output elasticities of factor inputs and productivity, we refer to the factors a_i , for $i = 1, \dots, 3$, as workers' interaction productivity. For the sake of simplicity, we also assume constant marginal return to scale, that is $a_1 + a_2 + a_3 = 1$, and we refer to interaction F2F, RS, and RA, as interaction 1, 2, and 3, respectively

Note that the Cobb-Douglas production function assumes inputs are complementary, i.e., firms need at least a small amount of all types of interactions.

2.1 Cost minimisation

The productive units of our model aim to minimise their costs, that is they solve the following cost minimisation problem:

$$\begin{aligned} \min_{X_1, X_2, X_3} & c_1 X_1 + c_2 X_2 + c_3 X_3 \\ \text{s.t. } Y &= a_0 X_1^{a_1} X_2^{a_2} X_3^{a_3} \end{aligned}$$

where c_1 , c_2 and c_3 are the marginal costs of the three interactions.

The Lagrangean of the cost minimisation problem can be written as

$$L(c_1, c_2, c_3, X_1, X_2, X_3, Y) = c_1 X_1 + c_2 X_2 + c_3 X_3 + \mu (Y - a_0 X_1^{a_1} X_2^{a_2} X_3^{a_3})$$

And its solution leads to the following first order condition system:

$$\begin{aligned} L_{X_1}: c_1 &= \mu a_0 a_1 X_1^{(a_1-1)} X_2^{a_2} X_3^{a_3} \\ L_{X_2}: c_2 &= \mu a_0 a_2 X_1^{a_1} X_2^{(a_2-1)} X_3^{a_3} \\ L_{X_3}: c_3 &= \mu a_0 a_3 X_1^{a_1} X_2^{a_2} X_3^{(a_3-1)} \\ L_{\mu}: Y - a_0 X_1^{a_1} X_2^{a_2} X_3^{a_3} &= 0 \end{aligned}$$

The optimal solutions as a function of total output, total factor productivity, and interactions' between productivity and costs, can be written as

$$\begin{aligned} X_1^* &= (Y/a_0) (a_1/c_1)^{a_2+a_3} (c_2/a_2)^{a_2} (c_3/a_3)^{a_3} \\ X_2^* &= (Y/a_0) (a_2/c_2)^{a_1+a_3} (c_1/a_1)^{a_1} (c_3/a_3)^{a_3} \\ X_3^* &= (Y/a_0) (a_3/c_3)^{a_1+a_2} (c_1/a_1)^{a_1} (c_2/a_2)^{a_2} \end{aligned}$$

and the total cost as

$$C := (Y/a_0) (c_1 (a_1/c_1)^{a_2+a_3} (c_2/a_2)^{a_2} (c_3/a_3)^{a_3} + c_2 (a_2/c_2)^{a_1+a_3} (c_1/a_1)^{a_1} (c_3/a_3)^{a_3} + c_3 (a_3/c_3)^{a_1+a_2} (c_1/a_1)^{a_1} (c_2/a_2)^{a_2}).$$

This is the minimum cost given that total output produced by the firm is Y .

Comparative statics on the optimal choices of the three types of interactions show that they depend positively on their own productivity (i.e., a_i , $i = 1, \dots, 3$) and negatively on their own cost (i.e., c_i). They as well depend negatively on productivity of the other types of interactions and positively on other types of interactions' costs.

2.2 Drivers of productivity and costs of interactions

In the rest of the model, we outline five key factors that can explain differences in costs (c_1, c_2, c_3) and productivity for the three types of interactions.

Commuting (g)

Due to the abatement of commuting, remote working saves time and money for both employers and employees. Employers can reduce office expenses like rents, maintenance, and energy bills. We are aware that this cost reduction can be enjoyed either by the firm or the worker. In Section 7 we discuss that this cost sharing could lead to poorer conditions for workers and what solutions

employers have to transfer this benefit to employees. Workers meeting through RS interactions do not need to meet physically in the same place, and they also do not need to synchronise their agendas if they use RA interactions. Then, this allows workers to save commuting time and expenses, i.e., RA and RS have higher productivity and lower costs.

We call g_1 , g_2 , and g_3 the firm's monetary gain due to lower cost associated to interaction F2F, RS, and RA, respectively. Then, we have that

$$g_1 < g_2 \leq g_3,$$

where the first inequality represents higher gains for firms if workers meet remotely, and the second weak inequality captures the idea that RA may be even cheaper than RS, e.g., through cheaper technology required and pecuniary benefits of no need of time synchronicity.

Considering these gains, costs for firms can be written as

$$c_1 > c_2 = c_1 - (g_2 - g_1)/g_1 \geq c_3 = c_1 - (g_3 - g_1)/g_1,$$

that is, the cost of RS and RS are discounted by their respective percentage gain, expressed in terms of monetary gain for F2F meetings.

Frequency of interactions (k)

Not only remote work activities save time and money (e.g., less commuting and better space/time allocation), but they also allow people to interact more often as a result of a more efficient use of time. Accordingly, we call this productivity gain for F2F, RS, and RA interactions k_1 , k_2 , and k_3 , respectively, and then we have

$$k_1 < k_2 < k_3.$$

Optimal time/place (v)

With remote working workers can choose the optimal time/space slot to work with RA interactions (and optimal space to work with RS interactions) and satisfy minimum time constraints if their work involves other people's works or deadlines. This flexibility allows workers to perform their tasks in the most favourable conditions compared to in-person meetings, where time and space are both constrained. We argue that this opportunity increases the productivity of interactions. This is not only because workers can be located in different continents and time zones. RA also allows workers to choose their best time and space allocation, given that productivity hours and therefore preferences over working hours may vary considerably across workers (Galinsky et al., 2001; Golden, 2012) and depend on external personal factors like heterogeneity in sleeping needs and habits (Rosekind et al., 2010; Giuntella et al., 2017). For instance, workers who feel more productive in the morning can schedule their activities in the morning, and similarly for those who are more productive at home or in other spaces or time slots.

Another advantage of RA interactions is the use of messaging services that allow all team members to keep up-to-date, also when only a few members are actively interacting, and this expedites circulation of ideas. As done for the other factors, we call v_1 , v_2 , and v_3 the additional productivity arising from F2F, RS, and RA, respectively, and we assume

$$v_1 < v_2 < v_3$$

Work-life balance (w)

With no commuting and the increased opportunity of meeting colleagues in the desired time/space slot, workers making use of the hybrid model enjoy less distress and better health conditions, and this contributes positively to their productivity. The work-life balance effect is obviously stronger for RA than RS meetings, given that in the former not only the (common) place but also the (simultaneous working) time constraint is removed. We argue that this opportunity increases the quality of workers interactions and productivity, and conveniently assume that

$$w_1 < w_2 < w_3,$$

where w_i is the productivity gain arising from a better work-life balance for each interaction $i = 1, 2, 3$.

Relationship decay (p)

While, on one hand, remote interactions make employees productivity higher, they may, on the other hand, reduce quality of relations among employees. This mainly occurs as remote meetings lack the richness of non-verbal and informal communication that can be particularly worth for relationships. In fact, emoticons used for messaging during remote interactions, especially RA ones, have been created exactly to address this problem. In this respect, Bicchieri and Lev-On (2007) resume the experimental game theoretical literature in social dilemmas and show that F2F communication helps focus on pro-social norms while it is harder to achieve the same outcome when communication is intermediated by web sources. Xiao and Houser (2005) argue that the higher possibility to express emotions in F2F interactions in presence raises the incentive for pro-social behaviour. Consistently, evidence from Becchetti et al. (2021) and Geraci et al. (2022) show that more time spent on the web or better broadband connection reduce social capital.

For each interaction type $i = 1, 2$, and 3, representing F2F, RS, and RA, respectively, we define the relational penalty p_i and we assume

$$0 = p_1 < p_2 < p_3,$$

that is, there is no relational penalty for F2F interactions, and the penalty is higher when interactions are asynchronous. We also note that the term p may capture other costs that harm productivity, like lower concentration in home settings, low quality digital infrastructure at home, uncomfortable place for remote working, or care responsibilities.

Based on what considered above, each interaction i is characterised by some marginal costs $c_i(g_i)$, that depend on the commuting factor g_i , and some productivity factor $a_i(k_i, v_i, w_i, p_i)$, that depends on the drivers affecting productivity. The combination of the frequency of interactions, optimal time/place slot, and work-life balance effects orders the three interaction types such that RA is more productive than RS, and RS is more productive than F2F, i.e., $a_3 > a_2 > a_1$. On the cost side, however, the mobility reduction and the relationship deterioration effect acts in opposite direction and therefore do not allow in principle to establish a clear-cut ranking.

To compute the optimal number of interactions, we assume productivity gains are constant, that is

$$k := k_i - k_j$$

$$v := v_i - v_j$$

$$w := w_i - w_j$$

$$p := p_i - p_j$$

$$\text{for } i = 2, 3, j = 1, 2, \text{ and } i > j.$$

In Table 1, we summarise the values we imputed for our analysis performed in the next section.

Table 1. Factors affecting costs and productivity and assumptions on their parameters

Productivity factor	Parameters	Impact	Model parameters
Commuting	$g_1 > g_2 > g_3$	Monetary cost	$c_1 > c_2 = c_1 - (g_2 - g_1)/g_1 > c_3 = c_1 - (g_3 - g_1)/g_1$
Frequency of interactions	$k_1 < k_2 < k_3$	Productivity gain (k)	$a_1 = 4 / (12 + k + v + w - p)$ $a_2 = 1 / 3$ $a_3 = 4 / (12 + 2k + 2v + 2w - 2p)$
Optimal time/place	$v_1 < v_2 < v_3$	Productivity gain (v)	
Work-life balance	$w_1 < w_2 < w_3$	Productivity gain (w)	
Relationship decay	$p_1 < p_2 < p_3$	Productivity loss (p)	

Notes: Model parameters assume costs and productivity gains and losses are constant for RS and RA meetings and they are meant to be expressed as percentage change from the unitary measure under F2F meetings.

3. Optimal number of meetings under different productivity scenarios

Employers use the cost minimisation problem to find the optimal number of F2F, RS, and RA meetings for their employees. These numbers crucially depend on several assumptions regarding the productivity for each type of meeting, their costs, and production size and economic efficiency.

Varying productivity

To analyse how meetings' productivity affects the number of meetings, we assume each meeting has the same costs equal to 1, and that total factor productivity is equal to 1 (this is reasonable for the major European economies, the US, and Japan, as shown by Calcagnini et al., 2021). We also set the output equal to 30, corresponding to the monthly production of one meeting per day for each meeting type if all meetings have the same productivity (i.e., $a_1 = a_2 = a_3 = 1/3$ and $X_1 = X_2 = X_3 = 30$, that lead to $Y = 30$).

To figure out how the optimal level of RSE interactions changes as a result of the trade-off between productivity gains and relationship decay, we assume the level of production, the total factor productivity parameter, and that costs are all equal and normalised to one. Output elasticities for each type of interaction are obtained as the share of productivity arising from each type of interaction out of the total productivity.

Table 2. Calibration of the model (homogeneous costs)

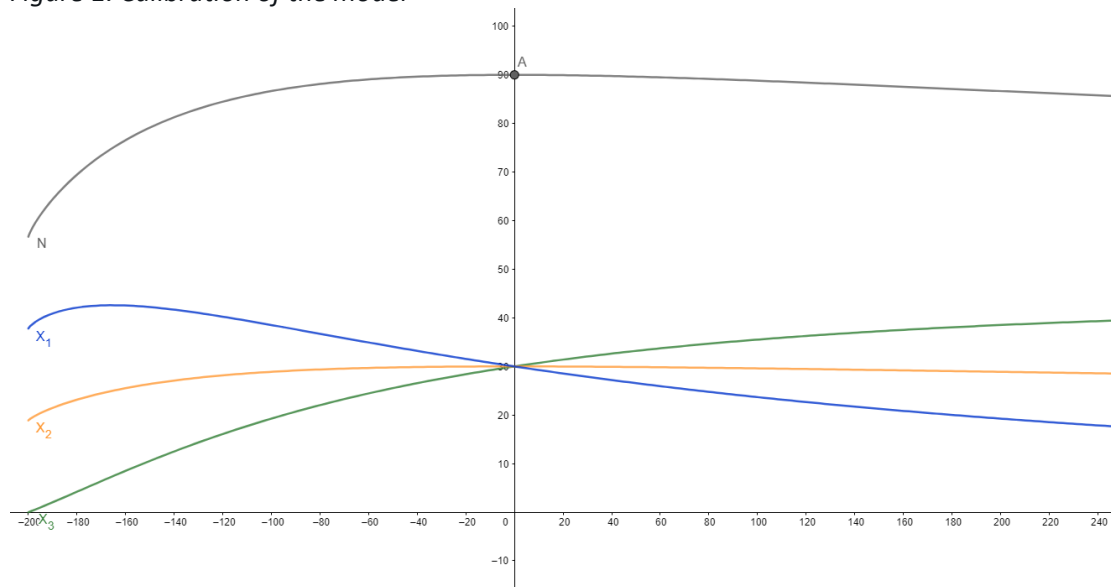
(productivity gain, relationship decay)	F2F	RS	RA	Total no. meetings	Share of RA
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(0,0)	30	30	30	90	0.33
(15,5)				89.98	
	29.26	29.99	30.73		0.34
(30,5)				89.90	
	28.20	29.97	31.73		0.35
(30,10)	28.55	29.98	31.40	89.93	0.35
(45,5)	27.20	29.92	32.64	89.75	0.36

Notes: F2F = face-to-face; RS = remote synchronous; RA = remote asynchronous; total factor productivity (a_0) = 1; Meetings costs (c_1 , c_2 , and c_3) = 1; Output (Y) = 30; Productivity parameter for f2f meetings (a_1) = $400/(1200 + k + v + w - p)$. Productivity gains are assumed to be homogeneous, i.e., $k=v=w$.

Table 2 shows the number of F2F, RS, and RA interactions that minimise firms' costs keeping production constant for different values of productivity gains (determined by the sum of the four productivity enhancing factors in remote relationships) and relationships decay. We can see that, while the number of RS meetings is almost constant, the number of RA meetings increases at the expenses of F2F meetings as productivity gain increases. Interestingly, the number of meetings also decreases. While this decrease is very small in magnitude, it is important to highlight that the introduction of remote meetings does not increase the overall number of meetings – they are actually reduced, with a very little change though; at larger scale (e.g., when the volume of meetings is higher and on a longer time period) this reduction can have an impact on both firms' management and employers' satisfaction.

Figure 1. Calibration of the model



Notes:

Vertical axis: number of interactions. Horizontal axis: difference between overall productivity gain and relationship decay ($k + v + w - p$). Grey line: total number of interactions; Blue line: face-to-face interactions; Yellow line: remote synchronous interactions; Green line: remote asynchronous interactions.

In Figure 1 we plot the number of F2F (blue), RA (orange), RS (green) interactions and the total interactions (grey) as a function of the difference between overall productivity gain and relationship decay (i.e., $k + v + w - p$). As noticed in Table 2, we can see that, as far as net productivity gain is positive and increases, the number of RS interactions also increases, reflecting the higher gain in productivity relative to the relationship decay. This is true until a maximum number of RA interactions, though with our imputed values this is extremely high. Differently, the total number of interactions is a decreasing function of positive net productivity gain (black line), even when RA

interactions increases. On the contrary, we can see that if the relationship decay is greater enough than productivity gain (in our example, the difference is -200 on the horizontal axis), then it is no longer convenient for the firm to use RS interactions.

If we assume RA interactions face lower costs than other types of interactions, we obtain a higher number of RA interactions for the same productivity difference, with the maximum number being reached at a lower difference (see Figure 2).

Varying costs

Another key parameter that drives the decision for more or less remote work is marginal cost. So far we have assumed the same unit marginal cost for each type of interaction. However, we can assume that remote interactions have fewer marginal costs compared to f2f interactions, especially when the majority of costs arise from office costs.

In Table 3 we report some values simulated using heterogeneous costs (i.e., $c_1 = 1$, $c_2 = 0.85$, and $c_3 = 0.7$). We observe that the total number of meetings is almost constant, as it was for the previous case. The share of RA meetings is now greater, capturing the efficiency gained through the cost abatement. When we assume no difference in productivity, firms should implement approximately 6 more RA interactions and 5 less F2F interactions to minimise costs, keeping RS interactions constant (Table 2, first row). We have also analysed the case where we do not have a productivity gain, assuming that productivity may decrease during remote interactions. Even under this scenario, the share of RA interactions remains higher than other interactions (i.e., 0.39) as well as higher than all previously simulated scenarios in Table 2.

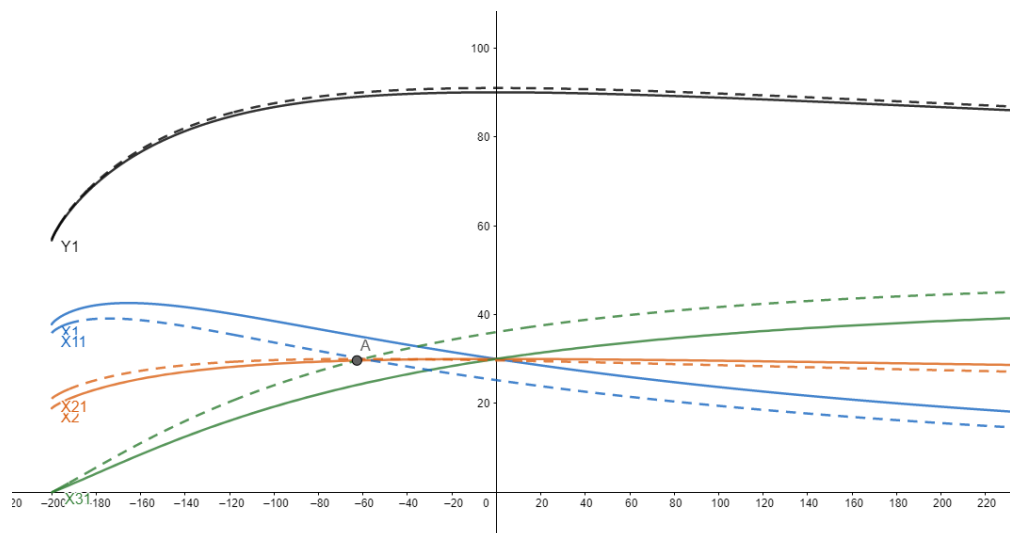
Table 3. Calibration of the model (heterogeneous costs)

(productivity gain, relationship decay)	F2F	RS	RA	Total no. Meetings	Share of RA
(0,0)	25.23	29.69	36.05	90.96	0.40
(30,10)	23.88	29.50	37.52	90.89	0.41
(-5,5)	25.95	29.77	35.22	90.94	0.39

Notes: F2F = face-to-face; RS = remote synchronous; RA = remote asynchronous; total factor productivity (a_0) = 1; Meetings costs: $c_1 = 1$, $c_2 = 0.85$, and $c_3 = 0.7$; Output (Y) = 30; Productivity parameter for f2f meetings (a_1) = $400/(1200 + k + v + w - p)$. Productivity gains are assumed to be homogeneous, i.e., $k=v=w$.

The overall dynamics is displayed in Figure 2, where the solid lines represent no. of interactions with homogeneous costs and the dashed lines represent no. of interactions with heterogeneous costs. We can see that the net productivity gain that makes the number of RA interactions equal to the number of F2F interactions is now negative and non-negligible in magnitude using our simulated values (approximately -60, point A). This means that the difference between productivity gains and relationship decay must be lower than -60 to have F2F interactions predominant in the business, while with homogeneous cost, this value was 0.

Figure 2. Number of interactions with different marginal costs.



Notes: Vertical axis: number of interactions. Horizontal axis: difference between overall productivity gain and relationship decay ($k + v + w - p$). Grey lines: total number of interactions; Blue lines: face-to-face (F2F) interactions; Yellow line: remote synchronous (RS) interactions; Green lines: remote asynchronous (RA) interactions. Solid lines assume marginal costs are all equal to 1; Dashed lines assume marginal costs are $c_1 = 1$ for F2F interactions, $c_2 = 0.85$ for RS interactions, and $c_3 = 0.7$ for RA interactions.

Comparison with a fully f2f firm

Let us assume the existence of a benchmark firm that does not allow workers to meet remotely, whose production function is therefore determined solely by the input of F2F meetings. A crucial assumption under this circumstance is constant returns to scale. On the one hand, we can assume constant returns to scale in the framework where only one (F2F) or two (F2F and RS) types of interactions apply, and this means these interactions are assumed more productive than in our benchmark model. On the other hand, we can assume interactions have the same productivity factors as in the benchmark (i.e., $1/3$), and therefore production has decreasing return to scale.

Table 4 shows how firms perform with no RA interactions. If we assume productivity for F2F interactions is still $1/3$, then the number of meetings necessary to keep the same production (i.e., $Y = 30$) at minimum costs is 2,700, extremely larger than the total number of interactions in our benchmark model (i.e., 90, see Table 2, first row). Even if we assume productivity of F2F interactions is twice as much that of the benchmark, the number of interactions is still much larger (i.e., 164). Assuming all meetings have unit costs, this means that firms' costs are also higher than in the benchmark model, and this cost difference increases if we reasonably assume remote interactions cost less than F2F interactions. More interestingly, if we assume two types of interactions with the same productivity as in the benchmark model (i.e., one third each), then the number of interactions is still higher by far (332.56 vs. 90).

Table 4 Cost minimisation comparison between a 100% F2F firm and a F2F/RS firm

Costs			Productivity			CRS	a0	Y	X1	X2	Total meetings	Total costs
1	2	3	a1	a2	a3							
Only f2f												
1			0.33			0.33	1	30	27,000		27,000	27,000
1			0.66			0.66	1	30	164.32		164.32	164.32
1			1			1	1	30	30		30	30

Only f2f and rs

1	1	0.33	0.33	0.66	1	30	164.32	164.32	328.63	328.63
1	1	0.5	0.5	1	1	30	30	30	60	60
1	0.85	0.33	0.33	0.66	1	30	151.49	181.07	332.56	305.4
1	0.85	0.5	0.5	0.66	1	30	27.66	33.06	60.71	55.76

4. Asymmetric information and remote work

In this section we extend our benchmark model introducing asymmetric information. We rely on Shapiro and Stiglitz (1984) shirking model that focuses on hidden action, i.e., workers' effort is unobservable for employers.

The firm in the original model is by assumption a fully F2F firm, and we know that an efficient wage has to satisfy the no-shirking condition (NSC), that is, working needs to be more convenient than shirking for the worker. The no-shirking condition can therefore be written as

$$V(n,e) > V(s,e)$$

where $V(n,e)$ and $V(s,e)$ represent the lifetime utility for a non-shirker worker and for a shirker worker putting effort in their productive endeavour, respectively. The above-mentioned lifetime utilities display the following dynamics:

$$rV(n,e) = w - e + b [V(u) - V(n,e)]$$

and

$$rV(s,e) = w + (b + qF) [V(u) - V(s,e)]$$

where w is the wage, e is the effort, $w - e$ represents the instant utility for the person, $V(u)$ is the lifetime utility for an unemployed person, b the exogenous quit rate, r the interest rate, q the probability of being caught shirking, and F the probability of being fired once being caught shirking.

Thus, NSC leads to the critical wage

$$w^o > rV(u)r + e (r + b + qF) / qF$$

and all workers earning more than w^o will not find convenient to shirk (Shapiro and Stiglitz, 1984).

This model can be applied to a company using remote working interactions with three main differences depending on characteristics of remote interactions described in section 3.1.

First, we assume employees put more effort during remote interactions, when they work at their optimal space (for both RA and RS meetings) and time (for RA meetings only) conditions. Consequently, productivity is higher for remote interactions than for F2F interactions, i.e., $e_{RS}, e_{RA} > e_{F2F}$. Our theoretical assumption is consistent with the empirical literature described in the introduction showing higher productivity for people working from home (see, among others, Bloom et al. 2015).

Second, employees in remote working settings enjoy additional benefits related to improved work-life balance, reduced mobility costs, and optimal time and place working slots. We indicate these amenities with $a_{RA} > a_{RS} > a_{F2F} = 0$.

Third, we assume that monitoring is more difficult when employees work remotely than when they meet in person, and therefore $q_{RA} < q_{RS} < q_{F2F}$. This assumption implies that not all workers' actions can be evaluated on observable outcomes that could be equally evaluated onsite or online. In other words, part of workers' effort contributing to current or future productivity (e.g., human capital formation or social capital created by good relationships with colleagues) is partly unobservable. Then, when employees work remotely part of their effort is even less observable, as it would be harder to monitor workers' investment in human and social capital when they are not onsite and their behaviour can be fully observed.

As a consequence, for each interaction i in $\{F2F, RS, RA\}$, we have

$$V(i,s,e) = [w_i + a_i + (b + q_i F)V(u)] / (r + b + q_i F)$$

$$V(i,n,e) = [w_i + a_i - e_i + bV(u)] / (r + b)$$

and the minimum wage required to exert effort is

$$w_i = rV(u) - a_i + [(r + b + q_i F)e_i] / q_i F \quad (1)$$

Comparative statics of equation (1) shows that wages for remote interactions can be increased proportionally to the productivity increase, decreased proportionally to the amenities related to teleworking, and increased as the probability of being caught decreased.

The relative weight of these offsetting effects will determine whether the efficiency wage of work at distance is higher than that of work in presence.

From this point of view, we can figure out two different scenarios. In the first scenario amenities of teleworking prevail and therefore the efficiency wage for remote interactions is lower than that for in-person activities. This scenario prevails when task performance is easily measurable, verifiable in the same way in presence and remotely, and when the remote working place creates all the most favourable conditions for teleworking (e.g., comfortable house, good broadband, lack of burden of domestic activities, lack of care responsibility, low noise pollution in the neighbourhood).

In a second scenario, there are no favourable working conditions and effort monitorability options for remote work. In that case, the efficiency wage must be higher for work at distance than for work in presence. In this case firms should verify if the additional asymmetric information cost of the higher efficiency wage for remote relationships compensates the productivity gains implied by these relationships, while there is no doubt in terms of benefits for the workers who enjoys both higher amenities and the monetary benefit of the efficiency wage.

In addition to it, when discriminating between RS and RA interactions, we consider that RS interactions have intermediate characteristics between F2F and RA ones. This is because benefits and amenities of telework are slightly reduced when meetings are synchronous, with respect to asynchronous interactions. Synchronicity prevents from choosing the optimal time/slot and adds more constraints on work-life balance. As well, we can consider that in RS meetings, effort monitorability is at an intermediate level between F2F and RA interactions.

To reconnect the asymmetric information with our benchmark model we can conclude that, together with the effect discussed in section 3, the wage differential determined between perfect and imperfect information equilibrium represents an additional effect of telework. The direction of this effect is not clear, though, as it depends on the relative strength of the two effects described above.

5. Discussion

The goal of an economic theoretical model is to understand real and complex economic systems and variable dynamics using a simplified mathematical framework with a limited number of assumptions that we deem essential to analyse the phenomenon under investigation. Accordingly, our model tries to capture production as a function of types of interactions assuming telework offers great opportunity to reduce costs and increase productivity. In this section we outline the limitations of our analysis and discuss other factors that may affect in-person and remote interactions, the impact that our findings have for wealth distributions and workers' rights, and how policymakers may support a just transition toward hybrid work.

Drawbacks and remarks of remote interactions

We are aware that our model cannot fit all types of business. For example, the construction industry or the artisanship sector are two sectors where remote and flexible working activities are very limited, and therefore the number of RS and RA interactions may need to be capped at some very basic levels, if positive. However, our model may particularly benefit other sectors where hybrid working conditions are feasible. This is the case of ICT, legal, financial, R&D, and education sectors, among others.

We assumed output is produced using a Cobb-Douglas technology, but in some contexts, this may be not appropriate. In fact, the assumption of complementarity of interactions is reasonable given their different features: F2F interactions contribute to create brand identity and quality of relationship, thereby making remote relationships more productive. However, some firms may find more suitable modelling their production using a linear or a Leontief production function. We believe that current firms' organisation and workers' tasks and preferences call for a function that require a minimum amount of each type of interactions, and this motivates our choice in the model.

Another important aspect is the number of interactions within the same unit or across different (and geographically distant) units. This concerns a narrower type of firms, though. Whether workers belonging to the same unit interact more often among them or with employees of other units may affect costs and productivity. On one hand, within-unit interactions may be cheaper and more productive, as they occur in the same place and among people that already know each other. On the other hand, between-unit interactions may also be cheaper and more productive, if they use comparative advantages and expertise of other units. Overall, we believe that remote interactions are more likely to occur when between-unit working activities are higher, as remote working conditions offer higher opportunities for people in different locations and with different schedules.

Working tasks and the possibility to move them remotely also depend on job types and seniority. For instance, managers are likely to have more interactions with colleagues belonging to other units or firms. As a result, some workers in assembly lines can only work onsite, while other workers can also enjoy remote. Similarly, junior workers or new staff may require more F2F interactions for learning by doing and building a good relational network within the company.

Teleworking options also depend on the quality of infrastructure in remote settings. Workers performing their tasks at home or in any other location outside the office need a proper working environment and often a high-quality broadband. Then, the opportunity to work remotely is massively affected by neighbourhood characteristics like noise pollution and broadband speed capacity and household conditions like care responsibilities and number of rooms. Moreover, one of the drawbacks of teleworking is the risk to blur the border between leisure and work activities, and lead to overexploitation of employees, especially junior staff.

In addition to the drawbacks mentioned so far, we also remark how costs for workers, firms, and the whole society may change as a reaction to higher share of teleworking. Several innovations in the digital sector such as the development of cloud storage and file synchronisation services made performing many tasks remotely at lower monetary and time costs and higher productivity. These advantages also have societal spillovers: first, they increase the exchange of the public good of information reducing the market failure of its socially optimal underproduction; second, they allow workers to increase the quality of their use of time, diversify the risk and reduce the cost associated to interactions that happen to be useless ex post.

More specifically on the impact on costs, the opportunity of moving from in-person to remote interactions can be seen as a (flexible work commuting) rent that can be shared between employees and employer (e.g., Google established that employers opting for teleworking have their wages reduced not to bear their lower cost of living and commuting).² This is particularly relevant in large cities, where relative house prices and congestions are higher (Croce and Scicchitano, 2022). Part of this rent is also represented by a reduction of workplaces in the office thereby generating a significant reduction of the office room required and therefore of corporate fixed costs.

Policy suggestions to regulate teleworking

All the challenging elements of hybrid working patterns, i.e., sector, job, seniority, and infrastructure, enhance economic and social inequality. To address this problem, both governments and firms shall acknowledge that teleworking can impact on inequality within firms and across industries, and monetary mechanisms to compensate such wealth differentials and different retirement conditions can be implemented.

More specifically on the role of governments, corporate decisions of moving to the hybrid model produce two positive externalities for environmental sustainability and workers satisfaction. While our model assumes that part of the effects of the work-life balance externality also benefits the company through higher productivity, the environmental externality is a pure positive externality. Consequently, the socially optimal share of remote relationships is higher than that obtained privately. The problem can be exacerbated in case of pandemics, when the reduction of contagion risk and outcomes represents another positive externality. All these externalities should be considered when evaluating teleworking from a multidimensional wellbeing perspective.

As for corporate policies, hybrid job contracts may change from unfair, inequitable, and discriminatory to just, worker-centred, and innovative with a few considerations. First, onboarding of newly hired workers should occur more often in office during the probational period, possibly together with their mentors. This would allow them to build their relationships with colleagues and familiarise with the tasks and the work peculiarities, and understand needs and challenging aspects of different types of work interactions. Second, firms should not expect any worker active outside the standard working time schedule (i.e., Monday to Friday, 9am to 5pm). This is in line with the right to disconnect, that has been discussed in several countries worldwide³ but still lacks a clear, homogenous regulation. Third, firms should consider economic disadvantages for those who can hardly or cannot work remotely, and wages should be adjusted accordingly. Monetary and non-monetary benefits for workers living in deprived areas or houses with uncomfortable working conditions, having caring responsibilities, or being impossible to work remotely because of their job tasks may be compensated using saved costs enjoyed by firms. Fourth, workers have heterogeneous

² <https://www.bbc.co.uk/news/business-58171716>.

³ See, for instance, the European Parliament resolution of 21 January 2021, accessible at https://www.europarl.europa.eu/doceo/document/TA-9-2021-0021_EN.html.

preferences for remote interactions, with some being extremely enthusiastic and others being more skeptics. This means – differently from what our model assumes – some workers may be more productive while others may slow down their production. Firms need to see teleworking as an opportunity for the former workers, in the interest of an optimal resource allocation for firms' and workers' objectives. Then, companies may offer their employees a wide range of contracts allowing teleworking activities to be concentrated in a given period of the year or spread out a few hours a day. Similarly to what happens for annual leave policies, that are designed to protect rights to work in the interest of both employees and employers, a fixed amount of remote working periods can be designed upon agreements between workers and their line managers.

6. Conclusions and direction of further research

With the digital revolution being at its greater expansion, a deeper understanding of how to manage teleworking options and their impact on workers' wellbeing and firms' outputs is urgently needed. In this paper, we model firms' decisions on how much workers should work onsite, remotely and simultaneously, or remotely and sequentially. More specifically, we outline and discuss the potential costs and benefits for firms and workers of moving from in-person to remote interactions. These can be summarised into five key features: cost saving, frequency of interactions, optimal time/space, work-life balance, and relational quality. Using an innovative Cobb-Douglas production function, we solve the optimisation problem of the hybrid company and find the optimal share of each type of interactions. We also calibrate our model using different input values and show that companies optimally replace in-person with asynchronous and remote interactions as long as (work life balance, optimal time/place slot, higher frequency of interaction) productivity gains outreach relationship decay. In a sense, remote synchronous relationships are dominated by remote asynchronous relationships unless we assume additional value of synchronicity. We finally compare the performance of a company choosing optimally among the three relationship types and a company constrained to onsite relationship, and highlights the significant efficiency gains of hybrid models.

Our work has several implications for corporate and governmental policies. First, our model may serve as first, benchmark theoretical framework that policymakers and managers can use to optimally choose their hybrid conditions according to measurable parameters. Second, companies should allocate in-person activities more for team building and workers' relationships than other practical tasks. This would maximise the effect of both onsite and online activities by increasing productivity and limiting relationship decay. Third, investment for universal access to high quality broadband could have a strong impact on corporate productivity increasing gains due to the possibility for workers to choose a higher share of second and third type relationships and, with them, their optimal time/space working slots. As is well known, universal access requires a proper governance of the industry given that profit maximisation companies have interest to invest only in high income areas while not on internal and rural areas, unless wages are adjusted accordingly. In this case, public resources like universal broadband access could also benefit from private investments that do not want to pay more people living in less connected areas.

Our theoretical analysis also aims to open directions for future research hypotheses that can be empirically tested. For instance, the COVID-19 pandemics and the associated lockdown measures represent a quasi-experimental setting that might show interesting results on how firms and people reacted to a massive jump into remote working. This has been done with unexpected, uncomfortable mental and household conditions, though. It would be also interesting to see in more ordinary post-pandemic times how corporate firms adjust their contracts, assuming that companies behave rationally and forward looking and maximise their profits. If hybrid options increase, this suggests a positive nexus between teleworking, productivity, and profits. More importantly, the

wellbeing of workers is another key point to further explore: understanding how they react in the short- and long-term, and how different infrastructure impact on their happiness is crucial for designing hybrid contracts.

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Appendix

Table A1. Companies adopting a hybrid model for remote work.

Company	Sector	Description of the policy	Source
Adobe	Software	50% of the employees are allowed to work from home.	https://www.techrepublic.com/article/adobe-announces-permanent-shift-to-hybrid-work-for-its-employees/
Amazon	Online retailer	Hybrid model with employees using teleworking options for 2 days a week.	https://www.cnn.com/2021/06/10/amazon-will-let-employees-work-remotely-two-days-a-week.html#:~:text=Amazon%20on%20Thursday%20relaxed%20its,office%20three%20days%20per%20week.
Benetton	Textile	Part-time remote working options both horizontal, vertical, and mixed, can be extended up to 20% of people. Flexible working options are made structural. Options to choose their preferred scheme for workers except of senior executives. Introduction of "Short Friday" with working time reduced by one hour.	https://www.ilsole24ore.com/art/nella-nuova-normalita-benetton-smart-working-piu-part-time-e-venerdi-breve-AEu8ijh
Capital One	Financial services	Flexible hybrid model without requiring employees to work at the office for a given number of days per week. Some employees are allowed to work from home entirely.	https://www.capitalone.com/about/newsroom/hybrid-work/
Coinbase	Crypto currencies services	Most staff who want to work remotely to do so indefinitely.	https://www.linkedin.com/pulse/18-major-companies-have-announced-employees-can-work-from-scott
Electrolux		All Italian sites work on a 60% seat capacity.	https://iusletter.com/oggi-sulla-stampa/smart-working-ondata-in-calo-800mila-rientrati-in-azienda/
Enel	Energia	All employees located in Rome will continue to work remotely. Call centre employees work at the office one week a month. While other job roles work in person 2 consecutive days a week.	https://roma.repubblica.it/cronaca/2021/08/28/news/smart_working_grandi_societa_riaprono_remoto_coronavirus_vaccini_aziende-315563806/
ENI	Energia/Gas	During the emergency peak of the pandemic, almost all workers used remote work options, including part of the staff of the operating sites. When restrictions have been eased, the share of remote workers was reduced to 50 percent.	https://www.corriere.it/economia/lavoro/cards/smart-working-cosa-succedera-italia-ottobre-proroga-dell-eni-cosa-fanno-altri/eni-orientata-mantenere-smart-working.shtml
Ericsson	Information and communication technology	Teleworking for 100% of the company population until October 2023, with the plan to allow every worker to work from home for up to 12 days a month.	https://www.corriere.it/economia/lavoro/cards/smart-working-cosa-succedera-italia-ottobre-proroga-dell-eni-cosa-fanno-altri/eni-orientata-mantenere-smart-working.shtml
Ferrero	Food	One day a week of remote work for all workers.	https://torino.repubblica.it/cronaca/2021/11/08/news/da_intesa_a_ferrero_sullo_smart_working_aziende_in_ordine_sparso-325505677/
Ferrari	Automobile	Massive use of flexible work. Ferrari, traditionally against teleworking, in two weeks was converted in order to allow 80% of indirect employees to work using hybrid options.	https://www.wired.it/economia/lavoro/2020/04/30/ferrari-fase-2-coronavirus/
Ford Motor	Automobile	Employees are allowed to work from home indefinitely with flexible hours. Hybrid work have been introduced for group meetings and projects where needed.	https://www.forbes.com/sites/jackkelly/2021/03/21/iconic-american-automaker-ford-motors-says-employees-can-work-from-home-indefinitely-with-their-new-redesigned-hybrid-in-office-and-remote-model/
Google	Information	In December 2020 the company announced a plan allowing its workers to work remotely for three days a week.	https://www.cnn.com/2021/05/05/google-relaxes-remote-work-

	and communicati on technology	In 2021, the company expected 60% of its employees work on site for a few days a week, 20% working in new office locations, and 20% entirely working from home.	plan-will-let-20percent-of-employees-telecommute.html
Intesa SanPaolo	Banking and financial sector	The company continues as per its 2016 agreement and provides up to 8 days a month of remote work.	https://www.today.it/economia/smart-working-grandi-aziende.html
Leonardo	Tech	Flexible working options are an integrated part of the organization. The company guarantees voluntariness, right to disconnect, periods of availability, and flexibility management for the workers, upon agreements with line managers.	https://www.ilsole24ore.com/art/lavoro-agile-40percento-imprese-continua-usarlo-anche-post-emergenza-AEeUqbHB
HubSpot	Marketing and sales platform	Employees can choose from three options: work from home with an approved home office setup, work from the office one or two days per week, or work from the office three or more days per week. New employees will have to choose their option prior to their start date and can change once a year.	https://www.flexjobs.com/blog/post/companies-switching-remote-work-long-term/
Lavazza	Food	The company offers the possibility to work remotely 1 day per week options since 2018. During the pandemic, this was increased up to 5 days per week. The intention is to maintain a hybrid scheme with 2 days per week.	https://torino.repubblica.it/cronaca/2021/11/08/news/da_intesa_a_ferrero_sullo_smart_working_aziende_in_ordine_sparso-325505677/
LogMein	Software	Some workers work remotely 100% of their time, while others have a hybrid arrangement. Depending on their role, a small percentage of employees work at the office four to five days per week.	https://www.logmein.com/it/newroom/press-release/2021/logmein-creates-new-digital-workplace-team-to-support-employee-and-customer-shift-to-hybrid-working
Microsoft	Technology	Employees can work from home for approximately 50% of their workweek. This can be extended to 100% upon line managers approval.	https://blogs.microsoft.com/blog/2021/03/22/the-philosophy-and-practice-of-our-hybrid-workplace/
Nationwide Insurance,	Financial Services	The company is making a permanent transition to a hybrid work model, with a majority of the staff being able to work entirely from home.	https://www.nytimes.com/2021/08/05/business/dealbook/remote-work-bias.html
Pirelli	Automobile	60% of the employees working remotely.	https://iusletter.com/oggi-sulla-stampa/smart-working-ondata-in-calo-800mila-rientrati-in-azienda/
Poste Italiane	Postal and financial services	From October 2021 all workers previously working from home are invited to return at the offices, except for vulnerable people.	https://www.today.it/economia/smart-working-grandi-aziende.html
Quora	Online Platform	The company has adopted a remote-first policy, allowing nearly all employees to work remotely and relocate to anywhere the company can legally employ them. The company will convert its existing office into a coworking space for employees who want to work there.	https://www.flexjobs.com/blog/post/companies-switching-remote-work-long-term/
Reddit	Online Platform	The company allows employees to choose permanent remote work, with options for in-office work in a casual environment.	https://www.flexjobs.com/blog/post/companies-switching-remote-work-long-term/
SalesForce	businesses of all shapes and sizes	Hybrid model. The company offers three categories of flexible work for its employees: flex (at the office one to three days per week), fully remote, and office-based (the small number of staff who need to be available in person four to five days per week).	https://www.flexjobs.com/employer-blog/salesforce-flexible-work-plans/
Siemens	Conglomerat e	140,000 of employees can permanently work from home for two to three days per week.	https://www.flexjobs.com/employer-blog/siemens-mobile-work-employees/#:~:text=Under%20the%20permanent%20plan%2C%20and,to%20three%20days%20a%20week.
Snam	Gas	The company has chosen to gradually bring workers back to all locations at least 2 days a week. As part of its health and safety protocol, the company has limited the maximum number of workers at the offices to 50%.	https://iusletter.com/oggi-sulla-stampa/smart-working-ondata-in-calo-800mila-rientrati-in-azienda/
Spotify	Real time communicati on	Hybrid model. Employees can choose to work at the office, remotely, or in a company-paid coworking space.	https://www.forbes.com/sites/kristinstoller/2021/01/31/never-want-to-go-back-to-the-office-heres-where-you-should-work/?sh=4ff488156712
Stellantis	Automobile	As of May 2021, about 90% of the Lingotto employees (i.e., approximately 6,500 employers) in Italy work remotely most of their time.	https://www.ripartitalia.it/stellantis-punta-sul-telelavoro-

		In the United States, Stellantis has launched a pilot project allowing 70% of the workforce to work from home. In Germany, Opel aims to reduce available workstations by 90% in order to drastically cut the number of offices and therefore real estate costs.	raggiunto-un-accordo-con-i-sindacati-francesi-per-dare-a-18-mila-dipendenti-la-possibilita-di-lavorare-da-remoto/#:~:text=Per%20mantenere%20queste%20percentuali%20oltre,casa%2C%2030%25%20in%20ufficio.
Tim	Telecommunications	At the end of the state of emergency, based on the union agreement set in 2020, all workers are expected to return to the office using teleworking options, i.e., for 3 days a week or 2 weeks a month.	https://iusletter.com/oggi-sulla-stampa/smart-working-ondata-in-calo-800mila-rientrati-in-azienda/
Unicredit	Banking and financial Services	The company starts a pilot project offering employees the opportunity to work from home 40% of their working time.	https://www.corriere.it/economia/lavoro/21_luglio_01/unicredit-smart-working-2-giorni-settimana-tutti-dipendenti-932b5d68-da77-11eb-b90a-fb70429ba8fb.shtml#:~:text=Unicredit%20si%20prepara%20a%20un,lavoro%20post%20pandemia%20saranno%20conclusi.
Unipol	Insurance	The company offers flexible work options for counter staff, subject to guaranteeing customer service.	https://iusletter.com/oggi-sulla-stampa/smart-working-ondata-in-calo-800mila-rientrati-in-azienda/
Verizon	Global communications	Hybrid model. The company is offering a range of remote options depending on job role.	https://buildremote.co/companies/companies-going-remote-permanently/
Zoom	Video communications	Hybrid model: the company strategically mix remote and in-office work.	https://blog.zoom.us/how-zoom-is-approaching-our-next-phase-of-work/
Windtre	Telecommunications	High flexibility in alternating between workplaces or other places and applies to all employees whose activities can be carried out remotely, including customer care staff. The smart working days may be requested by workers voluntarily, without constraints in terms of minimum or maximum size, and any days on which to go to the office will be identified with their manager, in order to stimulate social and relational interaction as a factor. of professional growth. The new work organization will be operational from 1 April 2021 until 31 March 2022.	https://www.windtregroup.it/IT/Press-&-Events/comunicati-stampa/Comunicati-Istituzionali/2021/WINDTRE_ACCORDO_SMART_WORKING.aspx?Source=https://www.windtregroup.it/IT/Press-&-Events/comunicati-stampa.aspx

Table A2. Company opting for 100% teleworking.

Company	Sector	Description of the policy	Source
Apple	IT	100%. Optional for some job roles during the pandemic; hybrid options when restrictions are eased.	https://www.computerworld.com/article/3652613/apple-joins-the-great-return-to-hybrid-work.html
Atlassian	Computer software business	100%.	https://www.linkedin.com/news/story/atlassians-workers-can-wfh-forever-4191073/#:~:text=The%20tech%20company%20Atlassian%20has,least%20the%20middle%20of%202021.
Facebook	Social media network	100%. All the employees can work from home permanently.	https://www.virtualvocations.com/blog/remote-job-leads/25-companies-going-remote-permanently/
Ford Motor	Automobile	100%. Employees will be allowed to work from home indefinitely with flexible hours. Hybrid work will be introduced for group meetings and projects where needed.	https://www.forbes.com/sites/jackkelly/2021/03/21/iconic-american-automaker-ford-motors-says-employees-can-work-from-home-indefinitely-with-their-new-redesigned-hybrid-in-office-and-remote-model/
Generali	Insurance	100% until the end of pandemic.	
Lambda	School	100%. The company has rolled out a permanent work-from-anywhere policy,	https://traqq.com/blog/here-are-

School	online	and employees can work from anywhere in the United States.	18-companies-that-have-switched-to-long-term-remote-work/#:~:text=Lambda%20School&text=The%20platform%20works%20uniquely%20in,long%20as%20it%20suits%20them. https://www.virtualvocations.com/blog/remote-job-leads/25-companies-going-remote-permanently/ https://www.forbes.com/sites/kristinstoller/2021/01/31/never-want-to-go-back-to-the-office-heres-where-you-should-work/?sh=4ff488156712 https://news.sap.com/2021/06/pl-edge-to-flex-future-of-work-at-sap/ https://www.forbes.com/sites/kristinstoller/2021/01/31/never-want-to-go-back-to-the-office-heres-where-you-should-work/?sh=4ff488156712 https://www.forbes.com/sites/kristinstoller/2021/01/31/never-want-to-go-back-to-the-office-heres-where-you-should-work/?sh=4ff488156712 https://www.forbes.com/sites/jackkelly/2022/03/05/twitter-employees-can-work-from-home-forever-or-wherever-you-feel-most-productive-and-creative/
Lincoln Financial Group	Financial Services	100%. All employees are eligible for permanent remote work.	
Shopify	E-commerce company	100%. All employees can work from home indefinitely.	
SAP	Software	100%. The company adopts a flexible, trust-based work model.	
Slack	Online learning	100%. Most of the employees can work from home permanently, and the company aims at hiring remote employees more permanently.	
Square	Financial services online	100%. Employees will be able to work from home permanently	
Twitter	Social network	100%. Employees will be able to work from home indefinitely, going to the office on a voluntary basis.	
Upwork	Freelance marketplace	100%. The company adopts a remote-first model, with remote work being the default for all employees.	
VMware	IT	100%. The company offers permanent remote working to all the employees.	https://www.flexjobs.com/remote-jobs/company/vmware