How do firms and workers respond to remote work?

Evidence from European Union

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Abstract

The impact that remote work has on productivity is a topic that reveals to be ambiguous in the existing literature, depending on the universe that is being considered, as well as the circumstances. Analyzing data at the country-level for 16 different European Union countries, with the use of country fixed effects to access what is, in fact, the impact that remote work has on productivity, our results indicate that working from home enhances productivity, both for workers and firms. However, with the fast increase in the percentage of people usually working from home during the COVID-19 pandemic, we also took conclusions about the influence that these circumstances had on the effect that remote work has on productivity. Our results from both of our models show that this impact decreased during 2020 and 2021, years when there were strict lockdown periods for the population.

Keywords: remote work, productivity, COVID-19 pandemic

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Resumo

O impacto que o trabalho remoto tem na produtividade é um tópico que revela ser ambíguo na literatura existente acerca do mesmo, dependendo do universo considerado, bem como das circunstâncias associadas. Ao analisar dados de 16 países diferentes pertencentes à União Europeia, utilizando "country fixed effects" para endereçar qual o efeito que o trabalho remoto exerce na produtividade, os nossos resultados revelam que, efetivamente, trabalhar por casa potencia a produtividade, tanto a de trabalhadores como a de empresas. Contudo, com o rápido aumento da percentagem de pessoas que normalmente trabalham remotamente durante a pandemia do COVID-19, nós decidimos retirar algumas conclusões acerca da influência que esse período exerceu no efeito que o trabalho remoto tem na produtividade. Os nossos resultados mostram, em ambos os nossos modelos, que este impacto diminuiu durante 2020 e 2021, anos onde houve períodos de quarentena para toda a população.

Palavras-chave: trabalho remoto, produtividade, pandemia do COVID-19

Título: Como é que as empresas e os trabalhadores respondem ao trabalho remoto? Evidência da União Europeia

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1 Introduction

Remote work was subjected to a lot of changes and it grew a lot within the last couple of years, especially after COVID-19. Essentially, during this time span and with the necessity of remaining at home for certain periods of time, there was an increase in the use of technology tools to cope with working and studying. Thanks to these tools and advances in technology, people were able to work from home to compensate the productivity levels, while keeping themselves and society protected from the virus.

So many things shifted after the pandemic, with the majority of firms changing the work arrangements from on-site to hybrid models of working. Under a hybrid work system, employees are supposed to work from home some days of the week and at the office on the remaining days. This shift led firms to adjust their expectations because if their employees are working from home, they cannot track the work that is done or the exact amount of time people are really working. Because of this lack of control, firms and employers would rather focus on specific goals and KPIs, instead of actual hours of work.

All these changes in the work arrangements brought more flexibility to the work system, allowing workers to have a better work-life balance, which is associated with well-being, and, consequently, productivity boosts.

Our motivation to make a study about this topic arises from the huge changes that the labour market suffered in this last couple of years. Because the literature about this topic is not consistent, with some authors affirming that working from home boosts productivity, and others stating that the relationship between the two is in fact nagative, we wanted to take our own conclusions and see if in some countries of the european union, working from home boosts or not productivity.

So the main question we ask ourselves is “Does remote work increase workers and firms productivity?”. In order to answer this question we used data from 16 different european union countries from official statistics: Pordata, Word Bank, ILO, and Eurostat. Our datasets are panel data with information about each one of the 16 countries for a 17 year span, that goes from 2006 to 2022, inclusive.

We believe our study will contribute to the existing literature, because the great majority of studies made about this topic focus their attention at some specific firms from specific countries, with the use of survey data. Our study broadens this point of view by using official statistics, and by focusing its analysis at the country-level, with the inclusion of 16 different european union countries. The fact that we don’t focus on survey data gives more reliability to

our results, and allows us to give some new insights to the literature about european union countries. Although our data is not too extended, we performed robustness tests and used clustered standard errors to enforce even more the reliability of our results.

After collecting the data, we constructed two models, model (1) to estimate the impact of usually working from home on workers' productivity, and model (2) to estimate the impact of usually working from home on firms' productivity. Our first model was inspired by the literature of *S.S. Deole et al., (2022)*. Here, we tried to include proxy variables for the control variables they use, in order to understand the impact that working from home has on productivity, measured by labour productivity per hour worked. To be able to perceive that, we controlled for individual characteristics, also including the income earned. In turn, our second model was inspired by the literature written by *Monteiro et al., (2019)*. With the use of a normalized production function, we tried to take conclusions about the impact that working from home has on productivity, measured by the output per hour worked. In our model, we made a proxy of some of the control variables used by *Monteiro et al., (2019)*, adapting to our reality and data, which differs from theirs. We controlled for ICT diffusion in the countries in general, including the internet usage, and we also controlled for manegerial practices. Besides, we also took into account workforce characteristics, and product market competition.

After estimating our models with the use of a fixed effects model, we concluded that, in fact, an increase in one percentage point of people usually working from home is associated with an increase in productivity by, 0.8% in the first model, and 0.7% in the second model, on average, across all countries, after accounting for country-specific effects.

Our work is organized in the following way: In section 2, we review relevant papers that were already made about the topic, highlighting the data they use, their methods, and their main conclusions. Then, in section 3, we explain our data in detail, as well as the empirical strategies we used. Furthermore, in section 4, we exploit our results, with the inclusion of robustness tests, and some extentions related with the COVID-19 pandemic. Lastly, in section 5, we finish our study with the inclusion of some final remarks.

2 Literature Review

A lot of studies were conducted to understand how remote work changed with COVID-19 and what were the implications of it in the labour organization, in terms of work regimes. Additionally, many authors decided to study what is effectively the impact of remote work on firms and workers' performance, in various countries around the world, without focusing their

analysis on the pandemic. Besides, many of them also tried to study the impact of this new work regime on the productivity of different sectors of activity. The majority of these studies were based on surveys collected to understand the pros and cons of remote work and how does it affect the performance at work.

2.1 Remote Work and COVID-19

J. Scott Marcus., (2022) studied the impact of the Covid-19 pandemic on remote work practices, particularly in developed countries. By using data from different surveys, the author concluded that the pandemic had a significant impact on the increase of remote work adoption, especially among educated workers. He states that although the necessary technology for remote work had been available before the pandemic, the restrictions and cepticism of employers limited the adoption of remote work regimes. The hybrid regime is the one adopted by the majority of the companies, where workers split their time between working at the office and working from home.

Furthermore, *Boutros et al., (2023)* examined the impact of remote work on firm performance specifically during the Covid-19 pandemic. To analyse it, they used a cross-sectional dataset from World Bank Entreprise Surveys (WBES), focusing on some Middle East and North African countries. However, due to the extreme effects that the pandemic had on Jordan and Morocco, they focused their attention on these two countries. Based on an ordered probit model, they used the propensity score matching method to address some potential selection bias and establish a causal relationship. They discovered that by starting to work remotely during the pandemic, firms' productivity increased by 0.472 percentage points. They also found that the impact of remote work on productivity was positive either in Jordan or in Morocco. However, only in Morocco, was this result revealed to be statistically significant.

Additionally, *Matteo Sostero et al., (2023)* studied the potential for teleworkability across European Union countries. By using various surveys to collect information about tasks, skills, organizational characteristics of occupations at a 5-digit level, work conditions and the prevalence of remote work during and after the pandemic, in general, they concluded that 36% of dependent employment in the EU has the possibility to provide remote work conditions. Besides, they also found that, before the pandemic, less than 5% of workers usually worked remotely and 10% did it only sometimes. Besides, they concluded that although the pandemic contributed to the exponential increase of remote work, once restrictions were over a lot of workers returned to in-office work. This suggests that the technological limits that occurred

before the pandemic, kept having an impact on the adoption of remote work after the pandemic period.

2.2 Remote Work and Productivity

In the literature there are a lot of studies about this topic, with some of them focusing on the impact of working from home and remote work on firms' productivity, while others explore this impact on workers' productivity. Furthermore, there are also a bunch of cases where the authors highlight the changes in working from home and productivity due to the mandatory lockdowns in 2020, caused by the COVID-19 pandemic, as we refered previously.

2.2.1 Remote Work and Firms Productivtity

Bloom et al., (2015) studied the impact of working from home on employee performance in China, using the difference in differences method. This method was applied to 996 employees who work at Ctrip's Shangai call center and the overall experiment occurred for 9 months. This universe of people allowed them to divide the people in two different groups in a random way: treatment and control groups. By doing it, they noticed that employees working from home revealed an increase of 13% in their performance, due to a rise in the number of minutes worked per shift and an increase in calls per minute. However, there was no difference found between the quality of the jobs of those who worked from home and those who were office-based. Additionally, their job satisfaction increased by 50% and the firm reduced their costs. Although there were a lot of positive aspects, the study also concluded that those who were in the treatment group and were working from home suffered from a reduction in promotion rates, compared to those who were office-based.

Another study that was conducted by *Allen et al., (2015)* studied the effectiveness of telecommuting using various sources of data from surveys, company records and experimental data. They found that workers who teleworked increased their productivity and job satisfaction, which led to an increase in the retention rates in the company. Besides, firms also increased their productivity and profitability.

Additionally, *Monteiro et al., (2019)* investigated the impact of working from home on firms productivity. To perform this, they used firm-level data from Portugal from the Community Survey on ICT Usage and E-Commerce in Enterprises from 2011 to 2016, establishing a relationship with data from the Portuguese Integrated Business Accounts System. Furthermore, they used a Cobb-Douglas production function to incorporate the data and

estimate some results. Those conclusions consisted of a negative average effect of remote work on productivity, with firms that have more skilled workers being able to take some positive aspects from remote work while those firms with more low-skilled workers were only able to see a negative impact on productivity, resulting from working from home.

Besides, *Sharma et al., (2023)* investigated the relationship between remote work outcomes and firm's performance, using empirical data from 128 IT professionals and applying multiple regression analysis. They found that remote work is extremely effective and enhances firm's productivity, only if the firm guarantees a bunch of materials that workers need to perform online.

2.2.2 Remote Work and Workers Productivity

Sumit S. Deole et al., (2022) explored the link between working from home and employees' performance during the COVID-19 pandemic in the UK. With the usage of representative data and the application of OLS, they concluded that the increase in work from home is positively related with employees' self-reported hourly productivity. Besides, they also showed that the variations in the frequency of work from home weren't associated with the number of hours worked per week. Additionally, they also revealed that females were more productive with the possibility of more flexible work arrangements, while males were more productive on-site.

Furthermore, *Etheridge et al., (2020)* studied the relations between workers' productivity during lockdown and working from home. In this paper, they used the Covid-19 module from the UK Household Longitudinal Survey that allowed them the usage of representative data on home workers' self-reported productivity. Their results revealed that, on average, respondents stated to be as productive as they were before the lockdown. Besides, they showed that sectors of activity where the possibility of remote work was small, revealed declines in their productive levels, as well as people with low earnings.

Moreover, *Rupietta et al., (2016)* investigated the impact of working from home on employees' productivity. With the use of the German Socio-Economic Panel (SOEP), and, consequently, applying an OLS model they found that working from home has a statistically significant positive impact on workers' effort. More precisely, they concluded that the more workers work from home, the higher their work effort and, consequently, productivity.

2.3 Hypothesis development

Hypothesis 1: ***Remote Work has a positive impact on workers productivity***

In the crossover[1] blog, there is an article written to understand "How is Remote Work Changing the Workforce?". In there, they state that remote work increases productivity and engagement. The authors have found that 81% of the employees who work in a hybrid[2] regime, 78% of employees who work in a full remote regime, and 72% of on-site employees reveal to be highly engaged. Although they state that remote work is associated with boosts in productivity, they have to be acompanied by well structured technological infrastures. If employees have the access to the right materials and tools, the probability of they being engaged is 2 times higher.

Hypothesis 2: ***Working from home brings more benefits than costs, either for workers and firms***

Nicole F. Church published a paper on the *International Journal of Business and Economic Development,* which consisted in what were the benefits of working fom home. On one hand, she concluded that the major benefits consisted in an increase in productivity, once the time that workers spend on travels to go to work can be used to do more work, and a decrease in sick days, once people could stay at home and recover properly, while working. Additionally, people could save costs because they don't have to invest in clothes and other accessories, if they are staying at home most of the week days, they also save time and travel costs decrease. On the other hand, there are some costs related with working from home, such as the managers perceptions, because when people work from home managers cannot witness their productivity, and, consequently start loosing visibility. Another cost is related with the lack of face-to face contact between coworkers, and the possible lack of self-discipline, because at home people might tend to get distracted by things that they enjoy doing.

As reported in *Ajay K. Garg et al., (2015)*, who studied the benefits and costs of employees working from home, by focusing their attention in a private company in South Africa, firms also save costs, in terms of infrastructure, electricity, water, air-condicioner, internet devices, cleaning ladies and security.

[1] Crossover is a human resources company which helps people to get a remote job opportunity.

[2] Hybrid work regime is the possibility of work remotely and on-site, while following the company's working rules.

3 Data and Variables

The data that was used consists in two different panel datasets, one to estimate the impact of working from home on the productivity of employees in 16 different european countries, which belong to the european union, and the other to estimate the impact of working from home on firms' performance, also from the same 16 european countries mentioned previously. Once both datasets have the same unique country identifiers, it is possible to outline countries over time and execute a panel data analysis.

The data was collected from different sources, including Eurostat, World Bank, International Labour Organization, and Pordata. However, when there was data missing on some countries in specific years, we searched for those values in official statistics sites from those countries. Furthermore, the time span of the main analysis goes from 2006 to 2022, in order to understand the trends of remote work and productivity before the COVID-19 pandemic and in the short-run after it.

The first dataset to estimate the impact of working from home on workers' performance, besides including data about productivity, measured by the labour productivity per hour worked, that correponds to the ratio between GDP in euros at current prices in the calendar year and the number of hours worked in the calendar year, and remote work, also has some variables to control for workers demographic characteristics. These include the residence status, the number of children, the urban population, and the educational level. Furthermore, a control variable for the income was also used.

The second dataset to estimate the impact of working from home on firms' productivity, measured by the output per hour worked, also has some variables to control for observable characteristics of the firms from different countries. These include the control for ICT diffusion in the countries in general, considering the internet usage, and the control for manegerial practices as the share of part-time workers. Furthermore, to control for workforce characteristics, the share of male workers, the total amount of people working in research and development activities, and the average levels of development associated with the skills of the firms workforce. Additionally, to also control for market competition a variable representing the exposure to international trade is also considered.

The 16 different european union countries are essential to the identification of the empirical strategy, relying on the estimation of fixed effects models.

In the empirical analysis, there is not a distinction between firms size or firms industry, once the goal is to elaborate these analysis and take conclusions for the countries as a whole.

Besides, the data we use is not directly related with specific information about firms, however, we use data at the country level in order to proxy for that reality.

3.1 Descriptive Statistics

In tables 1 and 2, there are represented the descriptive statistics for each dataset, where it is included the mean, median and standard deviation of the variables for all the 16 countries being analysed, and for the time period being considered, 2006 to 2022.

3.1.1 Descriptive statistics across Country and Time

Table 1 - Descriptive statistics from workers dataset

Variables	Mean	Median	sd
WFH[3]	4.39	2.85	4.56
Productivity[4]	34.81	30.25	20.45
College	30.29	30.70	8.82
Urban Population	70.15	68.47	9.37
1 Child	677.20	260.45	761.64
2 Children	658.17	238.30	738.03
3 or More Children	233.23	105.85	276.87
Income	13736.43	12981	7433.12
Living with a partner	4371.46	1700.80	5520.39

The mean of productivity across all countries and years is 34.81 and the median is 30.25. So the difference between the two is not too significant. The standard deviation of this variable is 20.45, indicating some variability of the data. Besides, on average, across all countries and years, the percentage of employees usually working from home is 4.39%, and the median 2.85%, values that are relatively close to each other. The standard deviation is 4.56, indicating small variability of the data of this variable, across countries and years.

Additionally, on average, around 30% of the population has a college degree and around 70% lives in urban areas, accounting for a 17 years period, and considering 16 countries.

Table 2 - Descriptive statistics from Firms dataset

Variables	Mean	Median	sd
Productivity[5]	51.9	47.53	18.92
Workers involved in R&D	129 188.9	56 555	173 494

[3] Percentage of employees usually working from home as a percentage of total employment.

[4] Labor productivity per hour worked (euros).

[5] Output per hour worked (GDP constant 2017 international $ at PPP).

Percentage Using Internet	75.69	78.25	13.42
WFH[6]	6.69	5.2	4.6
Share male workers	71.46	72	5.32
Average wage	299 654.4	100 712.6	443 271.1
Trade	111.12	103.01	42.87
Gross capital formation	1.514437e+11	5.692954e+10	2.056828e+11
Employment[7]	9 600.64	4 108.6	11 395.09
Part time	13.74	11.9	7.28

The mean of the output per hour worked is 51.9, and the median 47.53, so this variable might be slightly positively skewed. The standard deviation is relativelly high, indicating great variability of the data. In terms of WFH the mean is 6.69% and the median 5.2%. Besides, the standard deviation is 4.6, indicating small variability of the data across countries and years.

Given these results, we can see that, on average, around 71% of the employment corresponds to male workers. Besides, around 76% of the population uses internet, on average, and around 14% works part time.

3.1.2 Descriptive statistics by Country

Table 3 - Descriptive statistics from Workers dataset

Country	Mean WFH	Sd WFH	Mean Productivity	Sd Productivity
Austria	7.18	3.00	48.84	6.55
Czechia	1.40	1.24	19.64	3.88
Denmark	7.88	3.46	67.64	9.22
Estonia	4.55	3.48	18.42	5.30
Finland	9.64	6.46	51.33	5.83
France	7.58	3.24	52.02	4.25
Germany	3.93	4.72	49.84	6.60
Hungary	1.42	0.76	15.63	2.23
Ireland	6.12	9.26	71.34	23.20
Italy	2.22	2.94	38.89	2.96
Latvia	1.50	2.58	14.63	4.13
Lithuania	1.84	1.77	15.27	4.39
Poland	2.05	1.49	13.15	2.65
Portugal	4.63	3.98	20.99	2.41
Slovenia	5.31	0.93	25.33	3.63
Spain	2.94	2.40	33.98	2.92

[6] Percentage of employed persons working from home as a percentage of total employment.

[7] Measured in thousand persons.

In terms of productivity[8], the country with the highest mean, over time, is Ireland and with the smallest is Poland. In terms of variability, the standard deviation in Ireland is higher than in all of the other countries, 23.20, indicating high variablibility in productivity in this country over time. Contrarly to this, Hungary is the one with the smallest standard deviation, 2.23, leading to the conclusion that productivity levels haven't varied that much in this country between 2006 and 2022.

Furthermore, the country with the highest average percentage of employees usually working from home during the time period being considered is Finland, 9.64% and with the smallest is Czechia, 1.40%. Additionally, in terms of standard deviation, the country that shows the highest variability in the percentage of people working from home is Ireland, and the smallest is registered by Hungary.

Table 4 - Descriptive statistics from Firms dataset

Country	Mean WFH	Sd WFH	Mean Productivity	Sd Productivity
Austria	11.12	2.36	66.61	3.75
Czechia	4.02	1.47	40.27	4.12
Denmark	10.55	3.30	71.62	3.92
Estonia	6.55	3.42	36.15	4.92
Finland	13.09	5.61	64.55	2.18
France	9.87	3.16	65.71	2.52
Germany	5.83	4.50	62.8	3.59
Hungary	2.81	0.79	33.77	1.79
Ireland	9.34	8.46	93.12	24.18
Italy	4.32	2.39	62.75	0.54
Latvia	3.48	2.53	30.82	4.59
Lithuania	3.84	1.76	35.78	5.17
Poland	4.79	1.46	31.53	4.48
Portugal	5.72	3.94	39.09	2.4
Slovenia	6.95	1.42	42.69	3.32
Spain	4.77	2.30	53.17	2.96

When looking at the productivity levels measured by output per hour worked, it is possible to notice that the country with the highest mean between 2006 and 2022 is Ireland and with the smallest is Latvia. Moreover, the country with the highest standard deviation in its productivity levels is Ireland, indicating high variability of the statistics, fact that has strong impact on the mean value. Besides, the country with the smallest variability is Italy.

Furthermore, the country that, on average, revealed to have the highest percentage of employed persons usually working from home is Finland and the smallest percentage registered

[8] Represented Labour Productivity per hour worked.

belongs to Hungary. The country with the highest variability of this percentage, measured by the standard deviation is Ireland and the smallest belongs to Hungary.

3.1.3 Descriptive statistics within Time Period

Table 5 - Descriptive statistics from Workers dataset

Time	Mean WFH	Sd WFH	Mean Productivity	Sd Productivity
2006	2.44	2.22	27.21	16.41
2007	2.72	2.56	28.74	16.40
2008	2.78	2.48	29.56	16.14
2009	2.70	2.55	29.17	16.47
2010	2.93	2.72	30.37	17.01
2011	3.31	2.76	31.35	17.29
2012	3.41	2.74	32.11	17.76
2013	3.19	2.41	32.64	17.97
2014	3.11	2.30	33.67	18.58
2015	3.09	2.31	35.18	20.81
2016	3.08	2.24	35.58	20.75
2017	3.22	2.30	37.07	21.36
2018	3.36	2.33	38.34	21.85
2019	3.47	2.48	39.65	22.33
2020	10.41	6.13	41.65	24.97
2021	12.43	7.40	43.46	26.30
2022	8.93	6.38	46.29	27.77

Considering the measure of the descriptive statistics within time periods, it is noticeable the general increase of both, labour productivity per hour worked and percentage of employees usually working from home. This leads to the perception of a possible positive and significant relationship between the percentage of employees usually working from home and labour productivity per hour worked, on average.

Table 6 - Descriptive statistics from Firms dataset

Time	Mean WFH	Sd WFH	Mean Productivity	Sd Productivity
2006	4.68	2.87	45.81	16.48
2007	4.98	3.25	47.06	16.29
2008	5.10	3.16	47.18	15.92
2009	5.13	3.15	47.16	16.18
2010	5.44	3.28	48.51	16.66
2011	5.91	3.30	49.36	16.79
2012	5.94	3.17	49.80	16.72
2013	5.71	2.89	50.02	16.44
2014	5.63	2.78	50.65	16.94
2015	5.58	2.91	52.30	19.23
2016	5.46	2.83	52.39	18.77

2017	5.58	2.78	53.92	19.32
2018	5.86	2.91	54.78	19.56
2019	5.94	3.10	55.84	19.54
2020	12.32	6.15	58.00	22.81
2021	13.83	7.17	59.64	25.15
2022	10.65	6.26	59.94	25.68

In this case, considering the percentage of employed persons usually working from home and the output per hour worked, as a measure of productivity, we can take similar conclusions with both increasing in a paralel way over time, on average.

4 Methodology

The first empirical model, to understand the impact of remote work on workers' productivity, is inspired by the literature (e.g., S.S. Deole et al., 2022). So, the following model was estimated,

$$(1)\ \log(Y_{it}) = \alpha_0 + \alpha_1\, WFH\_usually_{it} + \beta X'_{it} + \epsilon_{it}$$

Where Y_{it} corresponds to the labour productivity per hour worked. $WFH\_usually_{it}$ corresponds to the percentage of employees usually working from home, with ages between 15 and 64 years old, as a percentage of total employment. X_{it} is a vector included in the regression to control for individual characteristics. These correspond to the residence status (the number of people living with a partner), the number of children (this considers the number of employed persons that have 1, 2, 3 or more children with less than 6 years old), the urban population (the percentage of population living in urban areas), the educational level (the percentage of people with a college degree). Furthermore, a control variable for the income (mean income before social tranfers) was also used.

The second empirical model, to understand the impact of remote work on firms' productivity, is inspired by the literature (e.g., Monteiro et al., 2019*[9]), following a normalized production function,

$$(2)\ \log(Y_{it}) = \alpha + \beta \log(K_{it}) + \gamma L_{it} + \theta\, WFH\_usually_{it} + \delta X'_{it} + \epsilon_{it}$$

Where Y_{it} is the output per hour worked, K_{it} is the gross capital formation, and L_{it} is the number of employed people. $WFH\_usually_{it}$ is the percentage of employed persons usually

[9] The empirical strategy of their paper follows the literature Bloom et al., 2019, who used a Cobb-Douglas production function.

working from home, as a percentage of total employment. X'_{it} englobes several observable characteristics of the firms in the different countries. These include the control for ICT diffusion in the countries in general, including the internet usage, that represents the percentage of individuals using internet, and the control for manegerial practices, which are represented by the share of part-time workers. Furthermore, to control for workforce characteristics, it was considered the share of male workers, the total amount of people working in research and development activities, and the average levels of development associated with the skills of the firms workforce, which is represented by the average wage that is paid to workers in the different countries being considered. Additionally, to also control for product market competition, a variable representing the exposure to international trade, which corresponds to the the sum of imports and exports as a % of GDP is also considered.

The empirical strategies that were adopted might be criticized due to some reasons. The first is the short length of our panel datasets, once we are making a study at the country-level, considering 16 countries and a 17 year time span. Nevertheless, we did robustness tests and used clustered standard errors to solve this problem. Secondly, the fact that the size of the firms and the different industry sectors were not accounted for might also be a limitation in our analysis. A way to bypass these questions would be to consider the percentage of employed persons working from home in the different sectors of activity and by firm size. However, these were not taken into account due to data limitations. Additionally, we used data at the country level as a proxy of data of all firms from each country, which is not the exact information from all the firms from all countries, nevertheless, we think that data of each country as a whole is a good proxy, because it takes into account all relevant information from all the firms of each country.

It is also important to consider that the time period ranges between 2006 and 2022. In 2020 there was the COVID-19 pandemic that increased the incidence of remote work, due to lockdown restrictions.

In both models, we divided the results in three different models, where in the first we didn't use any control variables, in the second, we added some, and in the third we have the full model with all the control variables mentioned before.

4.1 Fixed Effects Model vs Random Effects Model

The fixed effects method was used to make sure that the estimates were consistent. The Hausman test was made to compare the fixed effects model with the random effects model. This test was made to address if the country specific-effects are correlated with the regressors,

Hausman Test: $H_0: cov(x_{it} v_{it}) = 0 \; vs. H_1: cov(x_{it} v_{it}) \neq 0$

For the full model of (1), the results showed a *p-value* inferior to 1% in the full model, and in the model with only some control variables, so, it is possible to reject the null hypothesis and conclude that the country-specific effects are correlated with the regressors, which makes the Random effects model inconsistent. If we hadn't reject the null hypothesis, both models would have been consitent but the random effects model would have also been efficient. Although in the model without any control variable we didn't reject the null hypothesis, we chose to use the fixed effects model anyway, to be 100% sure that our results are consistent.

Moreover, by applying the same test to model (2), the results revealed a *p-value* smaller than 1%, in the smaller model and in the full model, and in the other one with only some control variables, a p-value slightly higher than 5%. Consequently, we decided to use the fixed effects model to estimate the results of all 3 models, in order to guarantee that the three estimations are comparable and consistent.

4.2 Tests for Heteroskedasticity and Autocorrelation

One of the main problems when dealing with panel data models is the possible presence of heteroskedasticity and serial correlation of the errors within individuals over time.

In our models, to detect if we do have heteroskedasticity in the residuals we used the Breush-Pagan test,

Breush-Pagan Test: $H_0: Homoskedasticity \; vs. H_1: Heteroskedasticity$

After applying this test, we noticed that in both of our models we are in the presence of heteroskedasticity, which might compromise our estimates.

Furthermore, we also tested for serial correlation in our models, by applying the Wooldridge's test for serial correlation in panel data models,

Wooldridge's Test: $H_0: No \; serial \; correlation \; vs. H_1: Serial \; correlation$

The results revealed that in both of our models we are in the presence of serial correlation.

To to solve these two problems, we decided to use clustered standard errors in all of our estimates, in order to achieve reliable estimates.

5 Results

We divided our results into 5 sections. In the first section, we focused on the results obtained from our models, to address the impact of usually working from home on productivity. Secondly, we tested the robustness of the results by controlling for external economic conditions, by other factors that might be related with productivity, and by substituting our dependent variables for other productivity measures. Furthermore, in the third section we exploited graphic representations of WFH and productivity measures in the various countries 2 years before the pandemic, in 2018, during the pandemic, in 2020, and 2 years after the pandemic, in 2022, and ran a fixed effects model to see if the pandemic influenced the impact of remote work on productivity in some way. Lastly, in the fourth section, we enumerated some benefits and costs associated with working from home arrangements.

5.1 The effect of Working From Home on Productivity

To address the question of what is the impact of usually working from home on workers and firms' productivity, we exploited the results obtained by running a fixed effects model in models (1) and (2).

5.1.1 The effect of WFH on Workers Productivity

Table 7 - Effect of WFH on Productivity in Model 1

	Dependent variable:		
	Productivity		
	(1)	(2)	(3)
WFH	0.027***	0.011***	0.008***
	(0.004)	(0.003)	(0.002)
log(income)		0.638***	0.429***
		(0.020)	(0.083)
College			0.016***
			(0.006)
Urban Population			-0.008
			(0.008)
1 child			0.00002
			(0.0001)
2 children			-0.0001
			(0.0001)
3 or more children			-0.0001
			(0.0001)
Living with a partner			0.00001
			(0.00002)
Country FE	yes	yes	yes
Observations	272	272	272
R2	0.326	0.842	0.896
Adjusted R2	0.283	0.831	0.886

Notes: Significance level at which the null hypothesis is rejected: ***, 1%; **, 5%; and *, 10%. The standard errors are clustered at country level.

Table 7 ilustrates the results of model (1), where the dependent variable is the log of labour productivity per hour worked, and the percentage of employees that usually work from home as a percentage of total employment is an indicator variable. Firstly, in the first column, we have the results of the model only including the main indicator variable, without including any control variable. Secondly, in the second column, there are represented the estimates of the model, where we control for the log of the income received per capita, once this factor is expected to have a direct impact on productivity. Furthermore, in the third model, we also control for individual demographic characteristics by adding variables, such as the the number of people who lives with a partner, the number of adults who have 1, 2, 3 or more children with less than 6 years at home, the percentage of the population living in urban areas, and the percentage of people with a college degree. Regarding the first model, the results show that the increase in one percentage point of employees usually working from home leads to a

statistically significant increase, at 1% level of significance, of productivity by $(e^{0.027} - 1) * 100 = 2.74\%$, on average, across all countries, after accounting for country-specific effects.

When looking at the estimates of the second model, it it possible to notice that the variable representing the percentage of employees usually working from home still has a statistically significant impact on the productivity measure, while the increase in 1% of the income leads to a 0.23% increase in productivity, on average, across all countries, after accounting for country-specific effets. Relatively to the third model, where we also control for individual demographic characteristics, the estimates indicate that an increase in one percentage point of employees usually working from home, as a percentage of total employment, leads to a statistical significant increase in productivity by $(e^{0.008} - 1) * 100 = 0.8\%$, on average, across all countries, after accounting for country-specific effects. The log of income per capita still affects positivelly productivity with 1% level of significance. Furthermore, having a college degree also impacts productivity positivelly, at a 1% level of significance.

5.1.2 The effect of Remote Work on Firms Productivity

Table 8 - Effect of WFH on Productivity in Model 2

	Dependent variable:		
	Productivity		
	(1)	(2)	(3)
log(gross capital formation)	0.269***	0.300***	0.184***
	(0.049)	(0.044)	(0.050)
log(employment)	-0.341	-0.331	-0.424
	(0.330)	(0.302)	(0.366)
WFH	0.014***	0.013***	0.007***
	(0.003)	(0.003)	(0.002)
Part-time		0.015**	0.004
		(0.006)	(0.005)
Internet usage			0.005***
			(0.001)
R&D workers			-0.00000
			(0.00000)
Male workers			0.003
			(0.003)
Wage			0.00000
			(0.00000)
Trade			0.002**
			(0.001)
Country FE	yes	yes	yes
Observations	272	272	272
R2	0.520	0.556	0.823
Adjusted R2	0.486	0.522	0.806

Notes: Significance level at which the null hypothesis is rejected: ***, 1%; **, 5%; and *, 10%. The standard errors are clustered at

Table 8 shows the results of the Cobb-Douglas production function model, using 16 countries that belong to the european union, when the dependent variable is the output per hour worked and the main indicator variable is the percentage of employed persons who usually work from home, as a percentage of total employment.

As we did to analyse the impact of remote work on workers' productivity, here, we also have three models, where in the first, we only use the gross capital formation and the number of people employed, as inputs to the basic Cobb-Douglas production function, and the percentage of employed persons usually working from home as our main explanatory variable. The results show that the variable representing remote work has a statistically significant positive impact on the productivity measure, with 1% level of significance.

In the second model, we include the percentage of people working part-time to control for human resources management practices. By including this variable, the impact of the percentage of employed persons usually working from home on the output per hour worked stays pretty much the same, with the coefficient dropping from 0.014 to 0.013.

Furthermore, the third model which is the most complete, because it not only accounts for human resources management practices, but it also considers the ICT diffusion by including the proportion of people using internet, and the workers characteristics by including the share of male workers in total employment, the share of part-time workers, the amount of people working in R&D activities, and the average wage paid to workers in representation of firms average level of skills. Adittionally, it is also included the trade as a percentage of GDP, as a measure of product market competition. By controlling for all these factors, the increase in one percentage point of the percentage of employed persons usually working from home leads to a statistically significant increase in the productivity measure by $(e^{0.007} - 1) * 100 = 0.7\%$, on average, across countries, after accounting for country-specific effects, and at a 1% level of significance.

5.2 Robustness Tests

In this section, we test the robustness of our results by adding different variables to models (1) and (2) to control for other factors that haven't been considered. We'll divide this section in 2 subsections, one to test the robustness of the results of model (1), and another to check the robustness of the results of model (2).

5.2.1 Robustness of the impact of employees WFH on productivity

In this subsection we checked the robustness of our results from model (1). To do it, we added a variable to control our model for external economic conditions. Besides, we also included a variable representing savings, once they have an impact on well-being, and, consequently, on productivity. Lastly, we modified the measure of productivity, by changing the dependent variable.

Table 9 - Effect of WFH on Productivity in Model 1: Robustness Tests

	Dependent variable:		
	Productivity		Hourly Productivity
	(1)	(2)	(3)
WFH	0.008***	0.005***	0.006*
	(0.002)	(0.001)	(0.003)
log(income)	0.424***	0.323***	0.146*
	(0.091)	(0.076)	(0.075)
College	0.016***	0.011***	0.011*
	(0.006)	(0.004)	(0.006)
Urban Population	-0.008	-0.011	-0.017*
	(0.008)	(0.009)	(0.009)
1 child	0.00002	-0.00001	-0.00004
	(0.0001)	(0.0001)	(0.0001)
2 children	-0.0001	-0.00002	0.00004
	(0.0001)	(0.0001)	(0.0001)
3 or more children	-0.0002	-0.0002	-0.0002*
	(0.0001)	(0.0002)	(0.0001)
Living with a partner	0.00001	-0.00001	0.00002
	(0.00002)	(0.00002)	(0.00001)
Unemployment	-0.001		
	(0.002)		
log(Gross domestic savings)		0.224***	
		(0.037)	
Country FE	yes	yes	yes
Observations	272	272	272
R2	0.896	0.932	0.763
Adjusted R2	0.886	0.926	0.741

Notes: Significance level at which the null hypothesis is rejected: ***, 1%; **, 5%; and *, 10%. The standard errors are clustered at country level.

5.2.1.1 External Economic Conditions

S.S. Deole et al., (2022) affirms that economic studies analyse variability in productivity between business cycles, leading to the conclusion that the fear of loosing a job leads to a boost in productivity. Once model (1) was inspired on their model, we constructed

our robustness check based on theirs. However, they controlled for local economic conditions by adding the local unemployment rate at the NUTS-3 county-level, while we controled for country economic conditions by using the countries' unemployment rates. So, we rewrote model (1), but now adding the unemployment rate to control for external economic conditions.

The results obtained after adding this new control variable are pretty similar to the ones analysed before, and the unemployment variable has a non statistically significant negative impact on the labour productivity per hour worked. Given these results, we cannot directly conclude that a higher unemployment rate leads to insecurity, which consequently affects negatively workers' productivity. However, the level of significance at 1%, and the coefficient of the variable *WFH* representing the percentage of employees usually working from home remained the same, fact that leads to the conclusion that the estimates are robust, and that working from home has a positive impact on productivity, even when there are tought external economic conditions.

5.2.1.2 Additional control variable – Savings

In their paper, *S.S. Deole et al., (2022)* also mentioned that well-being has a possible impact on workers productivity. In order to separate the impact of an increase in remote work on productivity, one of the control variables they added was the amount of savings. As inspiration, we opted to use this analogy to our data, using the gross domestic savings to check the robustness of our results.

The control variable added that represents the gross domestic savings measured in current local currency units has a statistically significant positive impact on productivity, fact that goes in line with the statement made by *S.S. Deole et al., (2022)* that well-being has a positive impact on productivity. Furthermore, the impact of the percentage of employees usually working from home on productivity drops slightly, from 0.8% to 0.5%, but keeps its level of significance, at a 1% level.

5.2.1.3 Alternative productivity measures

Furthermore, we also decided to use a different dependent variable, representing productivity, through the labour productivity per hour worked, with a unit of measure corresponding to index 2015=100, while the original unit of measure was in euros, correponding to the ratio between GDP in euros at current prices in the calendar year and the

number of hours worked in the calendar year. By doing this, we were able to test the robustness of the previous estimates.

By doing this change, the impact of the percentage of employees usually working from home on productivity, which in this case is represented by the labour productivity per hour worked (based on the index 2015=100), changes with now the increase in one percentage point of WFH leading to a positive increase of productivity by 0.6%, but only at a 10% level of significance.

5.2.2 Robustness of the impact of WFH on firms productivity

In this subsection we checked the robustness of our results from model (2). To do it, we added a variable to control for external economic conditions, as we did previously, a variable to control for governance effects, and we also used alternative productivity measures in our model.

Table 10 - Effect of WFH on Productivity in Model 2: Robustness Tests

	Dependent variable:			
	Productivity		log(Gross Value Added)	log(GDP)
	(1)	(2)	(3)	(4)
log(gross capital formation)	0.206***	0.110**	0.324***	0.017
	(0.052)	(0.051)	(0.077)	(0.018)
log(employment)	-0.413	-0.166	-0.041	0.719***
	(0.384)	(0.353)	(0.365)	(0.086)
WFH	0.007***	0.005**	0.008***	0.001
	(0.002)	(0.002)	(0.002)	(0.0004)
Part-time	0.001	-0.001	0.014	0.003**
	(0.004)	(0.003)	(0.009)	(0.001)
Internet usage	0.005***	0.001	0.009***	0.00001
	(0.001)	(0.001)	(0.002)	(0.0003)
R&D workers	-0.00000	-0.00000	-0.00000***	0.00000
	(0.00000)	(0.00000)	(0.00000)	(0.00000)
Male workers	0.008	-0.007*	0.012***	-0.009***
	(0.005)	(0.004)	(0.003)	(0.001)
Wage	0.00000	-0.000	0.00000***	-0.00000
	(0.00000)	(0.00000)	(0.00000)	(0.00000)
Trade	0.001*	0.001*	0.002**	0.0001
	(0.001)	(0.001)	(0.001)	(0.0002)
Unemployment	0.008			
	(0.005)			
log(GNI per capita)		0.376***		
		(0.068)		
Country FE	yes	yes	yes	yes
Observations	272	272	272	272
R2	0.830	0.884	0.892	0.796
Adjusted R2	0.812	0.872	0.882	0.776

Notes: Significance level at which the null hypothesis is rejected: ***, 1%; **, 5%; and *, 10%. The standard errors are clustered at country level.

5.2.2.1 External Economic Conditions

As it is possible to see, after adding the unemployment rate as a control variable to test the robustness of the results to control for external economic conditions, the results haven't change much, when compared to the previous estimation of this model. Therefore, even when including the unemployment rate to control for external economic conditions, the impact of working from home on productivity remained exactly the same, keeping its level of significance at 1%. This proves the robustness of the estimates obtained before that are not affected by external conditions of the economy. Furthermore, it is also noticeable that the unemployment rate doesn't reveal a statistically significant positive impact on productivity, measured by the output per hour worked. This result is not align with the economic literature stating that the increase in unemployment boosts productivity, due to the increase of the fear of job loss.

5.2.2.2 Governance Effects

Additionally, in the paper *Monteiro et al., (2019)* one of the things they use to check the robustness of their results are managerial effects. Once their reality is at the firm-level, we adapted to our reality and used governance effects instead.

It might be the case that variations in the percentage of employed persons usually working from home are related with variations at the country level that could affect productivity. So, changes in the policies of the countries might have an impact on the percentage of people usually working from home, which, consequently, might have an impact on productivity. Once changes in the governance of countries cannot be directly observed, we used a proxy variable that consists in the GNI per capita, measured at current local currency unit. In their paper, *Monteiro et al., (2019)* use CEO compensation per worker, and we consider that, adapting to our reality, Gross National Income per capita, measured in local currency unit, would be the best proxy variable to be used.

By controlling for the governance effects, the variable representing the percentage of employed persons usually working from home, still has a statistically significant positive impact on productivity, with a 5% level of significance.

5.2.2.3 Alternative productivity measures

The last robustness check consists in using two different alternative measures of productivity, gross value added in M€ and GDP per capita measured in current US$.

Firstly, we reestimated model (2), but instead of using the output per hour worked as a productivity measure, we used the gross value added. Even with the change in the dependent variable, the results didn't change much, with the percentage of employed persons usually working from home still having a positive and statistically significant impact on this new measure of productivity, at a 1% level of significance.

Secondly, we substituted the dependent variable of our initial model (2) to GDP per capita, as it represents the wealth generated by the entire production of goods and services in a country. By using this measure of productivity as our dependent variable, the results in terms of the impact of the percentage of employed persons usually working from home on productivity changed, with the impact loosing its significance, even if still positive.

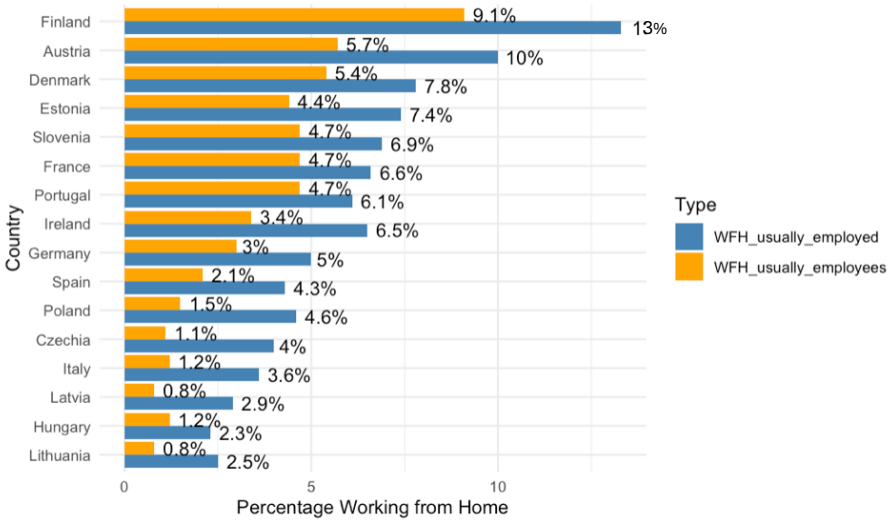
5.3 Pandemic, WFH and Productivity

5.3.1 Graphic representations of the differences across countries in WFH and Productivity

In this section, we exploit graphical representations from 2018, 2020, and 2022, of the sorted list of countries by percentage of emploees usually working from home and labour productivity per hour worked, for model (1), and percentage of employed persons usually working from home and output per hour worked, for model (2).

5.3.1.1 Before the COVID-19 Pandemic

Figure 1 - Percentage of Usually Working from Home in 2018, by country



When analising these figures, it is possible to see that, in 2018, 2 years before the 2020 lockdown due to the rapid spread of the corona virus, Finland was the country among the 15 other countries being studied that showed the highest percentage of employed persons and employees usually working from home, around 13% and 9%, respectively. However, this standout of Finland hasn't start only one or two years before the pandemic, it started a lot longer ago. In 1996, an official document, "*Working Hours Act*"[10] was released in Finland stating that workers can adjust their usual working hours by starting or finishing their work 3 hours earlier or later. After this, Finland adapted to remote work and flexibility way before the pandemic.

On the opposite extreme, Hungary was the country registering the smallest percentage of employed persons working from home, around 2%, in 2018. Before COVID-19, flexible work arrangements were not common in Hungary, with 31% of the companies not providing flexible work alternatives. Furthermore, in the first trimester of 2018, only 3.7% of all employees in Hungary were under flexible work arrangements. Budapest was the city that had the highest percentage of remote work, 10%, and the lowest was registered in North Hungary, 1.3%. In general, companies in this country were not supportive of remote work before the pandemic, fact that is related with the possibility of a decrease in efficiency, an increase in costs and the loss of control over employees.[11] In the percentage of employees working from home, Latvia and Lithuania are the countries at the bottom, around 1%.

[10] Document published in March 2011 by the Ministry of Employment and the Economy of Finland.

[11] The information contained in this last paragraph is from the "*Flexible working arrangements in Hungary*" document, provided by *OCDE library.*

In general, the countries that are more close to the east side of Europe were the ones where remote work before COVID-19 was less pronounced, while in the northern and central european countries the percentages were higher, even if the majority of them was below 10% of the total employment.

Figure 2 - Labor Productivity per hour worked in 2018, by country

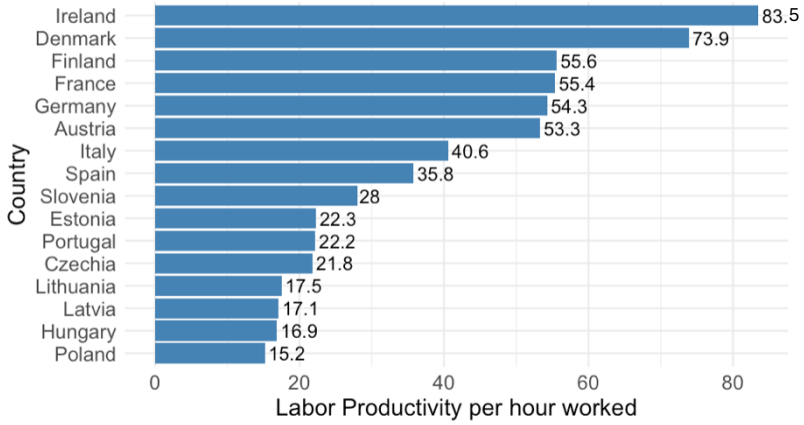
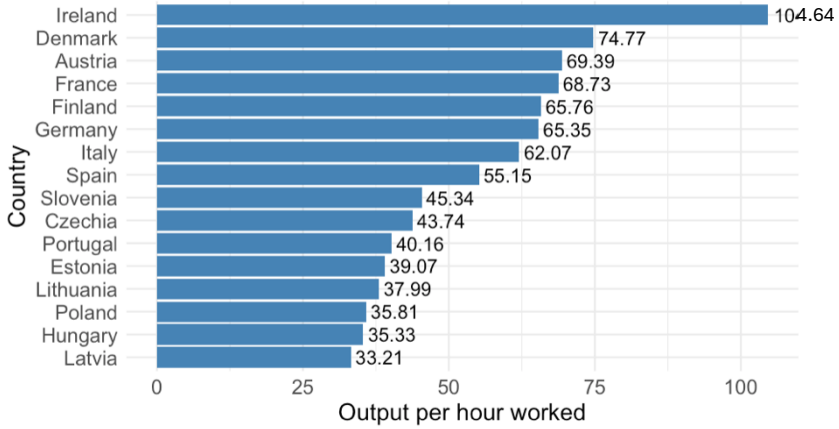


Figure 3 - Output per worker in 2018, by country

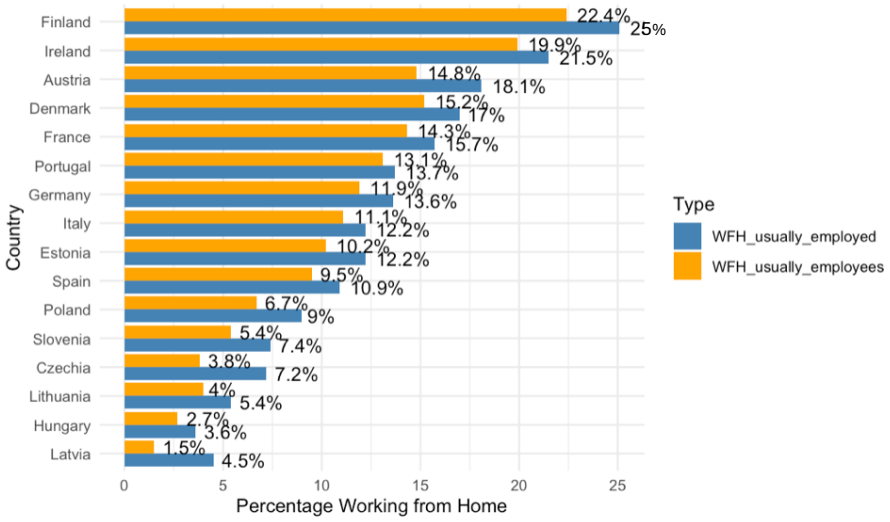


Nevertheless, Ireland's productivity levels, in 2018, were the highest of the 16 countries being considered, even if the percentage of employed persons working from home increase was the highest during this year, and Latvia the smallest.

By applying a different measure of productivity, such as the output per hour worked, Ireland dominates, with Latvia being last in the ranking. According to the figure, northern countries reveal to have higher values of output per hour worked, two years before the pandemic.

5.3.1.2 During the COVID-19 Pandemic

Figure 4 - Percentage of Usually Working from Home in 2020, by country



During the pandemic, there was a boost in the percentage of employed persons working from home in all countries, due to the mandatory lockdowns that were spread around the world. Finland kept being the country with the highest values of remote work, around 25%, and Hungary and Latvia the ones that registered the smallest values. Right after Finland, Ireland increased a lot its percentage of employed persons and employees usually working from home, with percentages around 22% and 20%, respectively.

Compared to the 2018 graph, Finland still earns the first place and Latvia the last in the percentage of employees usually working from home. However, although Latvia percentages haven't changed much, the percentages of employees usually working from home in Finland triplicated. We can also see that the northern countries, in general, were the ones with the highest percentage of workers usually working from home, and the easthern countries the ones with the smallest percentages.

Figure 5 - Labor Productivity per hour worked in 2020, by country

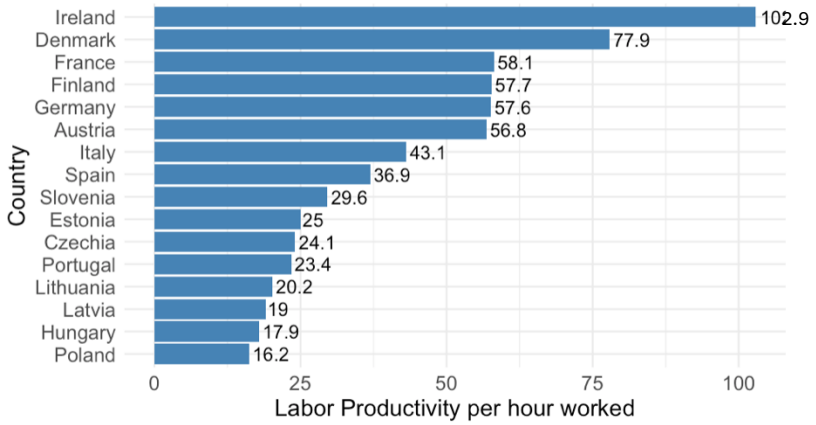
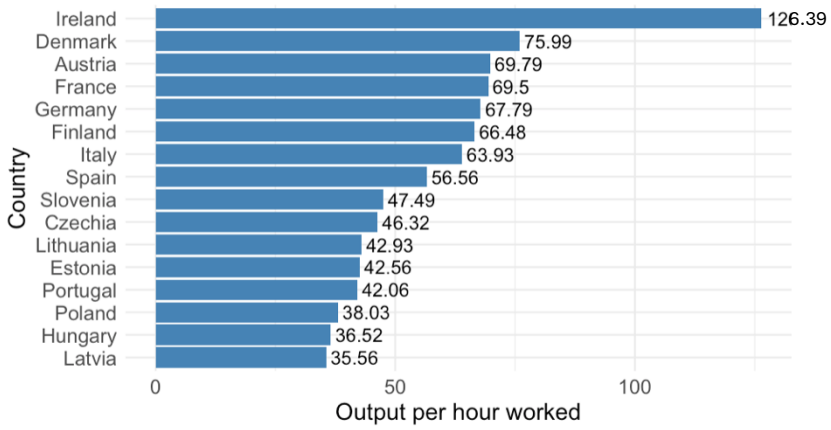


Figure 6 - Output per Worker in 2020, by country



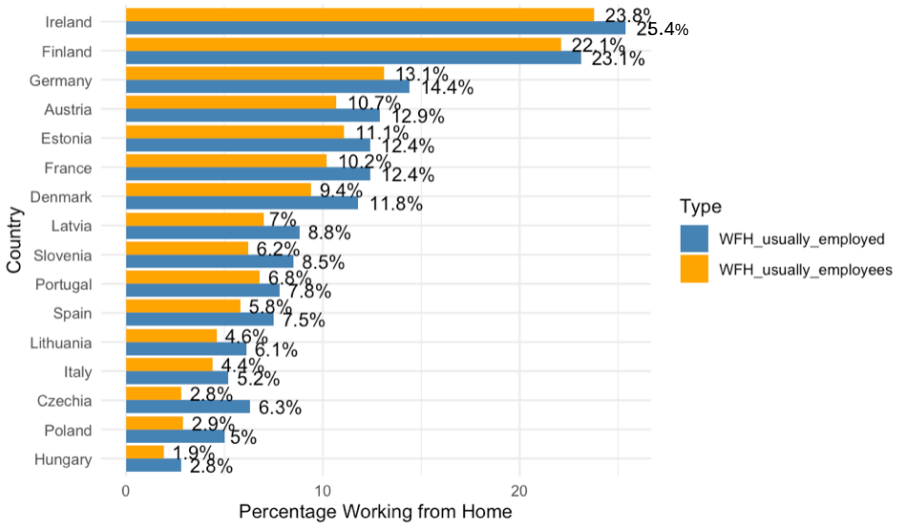
In terms of productivity, measured by the labor productivity per hour worked, Ireland gained the first position of the ranking in 2020, followed by Denmark. At the bottom of the ranking we have Latvia, Hungary, and Poland.

During 2020, even if a lot of countries have faced lockdown restrictions, the output per hour worked values were kept pretty stable with a slight increase, in general. Ireland was the country that showed the highest values of output per hour worked, followed by Denmak, while Latvia the country with the smalest value. In general, we can analyse that, in 2020, the northern european countries were the most productives, and the eastern ones the least productives. During the pandemic period, Ireland incorporated new tax relief measures so that workers could declare their expenses associated with Teleworking. Another important thing that happened in Ireland was the provision of financial support to businesses to adapt to the new working conditions.

Besides, Ireland integrated remote work as a public health measure, once it was a way to limit the spread of the virus, and, at the same time, provided support to businesses to develop teleworking. However, some countries, such as Italy or Spain, focused only on the need for a lockdown, not providing incentives to build remote work.

5.3.1.3 After the COVID-19 Pandemic

Figure 7 - Percentage of Usually Working from Home in 2022, by country



Two years after the pandemic, Ireland overtaked Finland and became the leader of the ranking, even if, in general, there was a decrease in the percentage of employed persons and employees usually working from home, among european union countries.

In 2022, althought most of the countries being considered showed a decrease in the percentage of employees usually working from home, Ireland increased even more its percentage, when compared to 2020.

Figure 8 - Labor Productivity per hour worked in 2022, by country

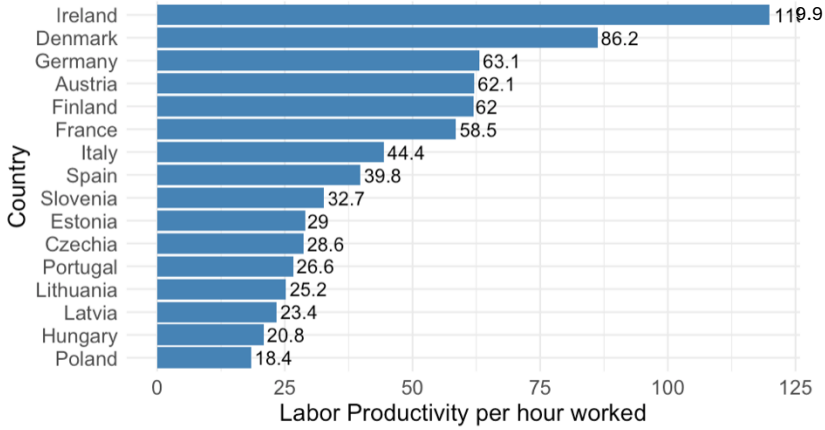
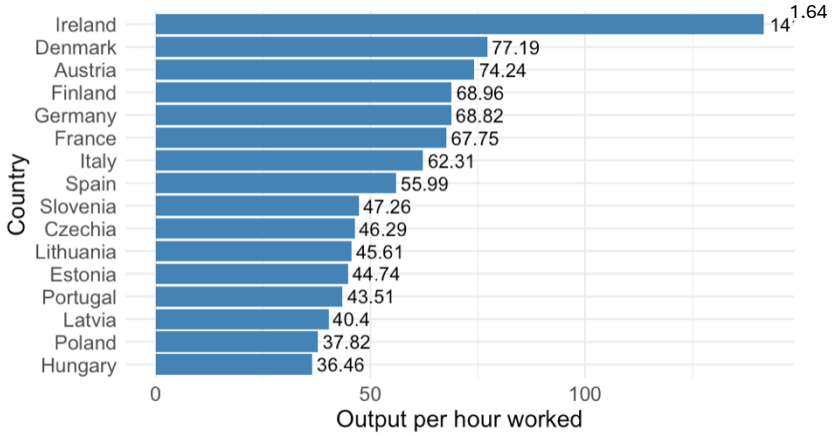


Figure 9 - Output per Worker in 2022, by country



In terms of labor productivity per hour worked, and output per hour worked, in 2022, Ireland was the one that had the highest change, with an increase of its levels of productivity. Ireland was proactive in promoting remote work in the early stages of the pandemic, a fact that differentiates it from some of the other countries that didn't act right away. In January 2021, Ireland launched the National remote work strategy, which helped implement remote work, providing the necessary conditions for workers to work remotely in the long term. After the pandemic, Ireland decided to adopt a hybrid work system with a mixture of office-based days and remote days, a fact that increased flexibility and a good work-life balance for the employees.

5.3.2 Impact of WFH on Productivity during COVID-19 lockdowns

To see the impact of working from home on productivity measures during the pandemic, we added a new variable to the datasets. This variable is called *covid* and is equal to 1 in 2020 and 2021[12], and equal to 0 otherwise. So, our new models are the following,

(3) $\log(Y_{it}) = \alpha_0 + \alpha_1 WFH\_usually_{it} + \alpha_2 covid_t + \alpha_3 WFH\_usually_{it} * covid_t + \beta X'_{it} + \epsilon_{it}$

(4) $\log(Y_{it}) = \beta_0 + \beta_1 \log(K_{it}) + \beta_2 L_{it} + \beta_3 WFH\_usually_{it} + \beta_4 covid_t + \beta_5 WFH\_usually_{it} * covid_t + \delta X'_{it} + \epsilon_{it}$

[12] Years when there were lockdowns due to the pandemic.

We used a fixed effects model to make the analysis, and obtained the following results in models (3) and (4), respectively,

Table 11 - Effect of WFH on Productivity: Influence of COVID-19

	Dependent variable:
	Productivity
WFH	0.014***
	(0.002)
WFH*covid	-0.004***
	(0.002)
Other controls	yes
Country FE	yes
Observations	272
R2	0.907
Adjusted R2	0.898

Notes: Significance level at which the null hypothesis is rejected: ***, 1%; **, 5%; and *, 10%. The standard errors are clustered at country level.

The results of model (3) revealed that the increase in one percentage point of employees usually working from home leads to a statistically significant increase in productivity[13] by 1.4%, on average, across all countries, after accounting for country-specific effects. Furthermore, the interaction term is statistically significant, indicating that the impact of working from home on productivity significantly decreased during the lockdown years, 2020 and 2021, when compared to the other time periods.

[13] Labor productivity per hour worked.

Table 12 - Effect of WFH on Productivity: Influence of COVID-19

	Dependent variable:
	Productivity
WFH	0.009**
	(0.003)
WFH*covid	-0.003***
	(0.001)
Other controls	yes
Country FE	yes
Observations	272
R2	0.826
Adjusted R2	0.807

Notes: Significance level at which the null hypothesis is rejected: ***, 1%; **, 5%; and *, 10%. The standard errors are clustered at country level.

When looking at the results of model (4), it is possible to see that the impact of the percentage of employed persons usually working from home on productivity[14] is similar to the one obtained in the previous model, (1). Furthermore, in this model, the interaction term is statistically significant and negative, revealing that the impact of employed persons usually working from home on productivity, changed negatively during the lockdown periods, when compared to the other time periods.

5.4 Main Benefits and Costs of Working From Home

In this section we enumerate some pros and cons of working from home.

5.4.1 Main Benefits of Remote Work

- **Flexibility and Work-Life Balance:** Remote work allows the criation of more flexible schedules, allowing people to organize their time in the best way to balance with their personal lives.
- **Cost Savings:** When people decide to work from home there are a lot of costs savings, either for employees and employers. Employees don't need to spend money on

[14] Output per hour worked.

commuting costs and employers are able to save costs at the office, such as electricity and water.

- **Time saving:** A lot of people spend a lot of time of their days getting ready for work and on traffic, so, working remotely helps them save a lot of time to make other tasks and increase their productivity.
- **Access to a wide Job Market:** Remote work creates opportunities for workers to work for companies anywhere in the world and not limit their options because of their geographic location.

5.4.2 Main Costs of remote Work

- **Limited Social Networking:** Building relationships with colleagues can be limited when working from home. This might lead to difficulties in team work and share of ideas.
- **Reduced Career Progress Opportunities:** When people work remotely it is more difficult to progress in their careers, because directors and managers cannot directly see the work that has been done.
- **Technical Issues and IT support:** Remote workers may face technical issues, such as hardware problems, without having someone solving immediately the issue.

6 Conclusion

Working from home is a type of work arrangement that gain its major significance after the COVID-19 pandemic. In 2020 and 2021, there were lockdowns and strict restrictions that were associated with the closure of schools, shoppings, and work places. Firms had to adapt rapidly to this change, and started to operate remotely. In 2022, the restrictions ended, however, a lot of firms and jobs started to implement hybrid work arrangements, with some days of the week working on-site, and others at home.

Working from home created flexibility in the lives of workers, allowing them to coordinate their personal lives with their professional lives in a better way. Some study has been made about the topic “Does remote work enhances productivity?”, and in fact a lot of positive conclusions have been taken. A lot of studies concluded that work arrangements that include working from home are associated with higher productivity, on both, the worker’s side, and the firm’s side. However, it can’t be denied that some studies concluded the opposite,

revealing that, in their specific context, working from home and remote work don't boost productivity.

The great majority of studies made about this topic focus their attention on some specific firms from specific countries, with the use of survey data. Our study broadens this point of view by using official statistics, and by focusing our analysis at the country-level, with the inclusion of 16 different european union countries. The fact that we don't focus on survey data gives more reliability to our results, and allows us to give some new insights to the literature about european union countries. Besides, our results can also help operationalise efficiency, because understanding if working from home impacts productivity allows the optimisation of costs and management.

Our study was inspired by two different papers, *S.S. Deole et al., (2022)*, and *Monteiro et al., (2019)*. The first focuses on the link between working from home and employees' performance during the COVID-19 pandemic in the UK, while the second focuses on the impact of working from home on firms' productivity. They focused on representative data, using self-reported productivity levels of workers from the UK, and firm-level data from Portuguese firms from the Community Survey on ICT Usage and E-Commerce in Enterprises, respectively. By using these sources of inspiration, and adapting to our reality, we obtained relevant results that can contribute to the literature about this topic. If we only look at the impact that working from home has on productivity, without controling for any other variables, we obtain a positive and statistically significant impact of *WFH* on productivity on both models, but as we include more control variables, that impact decreases, however, it doesn't loose its significance nor its positive sign.

As we dig deeper into our results, we see the influence that the pandemic had on the impact that working from home has on productivity measures. Once we included an interaction term in our models between the *WFH* variable, and the *covid* variable[15], we were able to see that the impact that working from home has on productivity significantly decreased during 2020 and 2021, due to COVID-19.

Although our results go in the direction of our expectations, they might have some limitations caused by the short length of the panel, with only 16 countries, and a time period of 17 years. However, we tried to bypass this situation by doing tests of robustness and by using clustered standard errors to eliminate any heteroskedasticity or correlation within countries.

[15] Variable that is equal to one in 2020 and 2021, due to lockdowns caused by the COVID-19 pandemic.

Despite this drawback, we think that our work will have a significant contribution to the existing literature, providing a more general analysis at the country-level. With our results, we expect to help mitigate some doubts related with the best work regimes that should be adopted by firms and workers, providing insights that full on-site work is not the future, once due to the COVID-19 pandemic, the world and, in particular, european union countries adapted with high speed to the new reality of remote work. The fact that workers don't have to go to the office every single work day, allows them to have the flexibility to organize themselves and their lives in the most efficient way. Besides, workers who work at metropolitan areas save a lot at the end of the month with transportation costs, which helps them save more, and consequently improve their well-being and productivity, as we proved in one of our robustness tests. Additionally, firms can also save costs in terms of electricity and water once they won't have all their employees at the same time at the office.

So, our study allows us to see that, in fact, working from home has a positive impact on productivity, result that is confirmed by both of our models.

7 Bibliography

[1]. Aksoy, C. G., Barrero, J. M., Bloom, N., Davis, S. J., Dolls, M., and Zarate, P., 2023. "Working from Home Around the Globe: 2023 Report". econPOL Europe. Link: https://www.econpol.eu/sites/default/files/2023-07/EconPol-PolicyBrief_53.pdf

[2]. Alipour, J.-V., Falck, O., and Schüller, S., 2020. "Germany's Capacities to Work from Home". CESifo Working Paper No. 8227. Link: https://www.researchgate.net/publication/340771802_Germany's_Capacities_to_Work_from_Home

[3]. Allen, T. D., Golden, T. D., and Shockley, K., 2015. "How Effective Is Telecommuting? Assessing the Status of Our Scientific Findings". Psychological Science in the Public Interest 16(2):40-68. Link: https://www.researchgate.net/publication/282160075_How_Effective_Is_Telecommuting_Assessing_the_Status_of_Our_Scientific_Findings

[4]. António, D. S., Dimitris, G., and Marco, W., 2023. Published by European Central Bank, "How people want to work – preferences for remote work after the pandemic". Link: https://www.ecb.europa.eu/press/economic-bulletin/focus/2023/html/ecb.ebbox202301_04~1b73ef4872.en.html

[5]. Barrero, J. M., Bloom, N., and Davis, S. J., 2023. "The Evolution of Work from Home." Journal of Economic Perspectives, 37 (4): 23–50. Link: https://www.aeaweb.org/articles?id=10.1257/jep.37.4.23

[6]. Bloom, N., Liang, J., Roberts, J., and Ying, Z. J., 2015. Published by Oxford University Press. “Does Working From Home Work? Evidence From a Chinese Experiment”. The Quarterly Journal of Economics. Link: https://www.jstor.org/stable/10.2307/26372598

[7]. Boutros, P., Fakih, A., Tarraf M., 2023, “Adapting to the new normal: The impact of remote work on firm performance in Jordan and Morocco”. Regional Science Policy & Practice. Link: https://doi.org/10.1111/rsp3.12667

[8]. Deole, S. S., Deterb, M., and Huang, Y., 2023. “Home sweet home: Working from home and employee performance during the COVID-19 pandemic in the UK”. Labour Economics Journal, Vol. 80. Link: https://doi.org/10.1016/j.labeco.2022.102295

[9]. Dingel, J. I., and Neiman, B., 2020, “How many jobs can be done at home?”, Journal of Public Economics. Link: https://doi.org/10.1016/j.jpubeco.2020.104235

[10]. Etheridge, B., Wang, Y., and Tang, L., 2020. “Worker productivity during lockdown and working from home: Evidence from self-reports”. ISER Working Paper Series, No. 2020-12, University of Essex, Institute for Social and Economic Research (ISER), Colchester. Link: https://www.econstor.eu/bitstream/10419/248579/1/2020-12.pdf

[11]. Eurostat. Employed persons working from home as a percentage of the total employment, by sex, age and professional status (%). Link: https://ec.europa.eu/eurostat/databrowser/view/lfsa_ehomp__custom_12669053/default/table

[12]. Eurostat. Labour productivity per hour worked - annual data. Link: https://ec.europa.eu/eurostat/databrowser/view/tipsna70__custom_12962253/default/table

[13]. Eurostat. Mean and median income before social transfers (pensions included in social transfers) by age and sex. Link: https://ec.europa.eu/eurostat/databrowser/view/ilc_di13__custom_12729916/default/table

[14]. Eurostat. Number of adults by sex, age groups, number of children, age of youngest child and working status (1 000). Link: https://ec.europa.eu/eurostat/databrowser/view/lfst_hhacwnc__custom_12782813/default/table

[15]. Eurostat. Number of persons by sex, age groups, household composition and working status (1 000). Link: https://ec.europa.eu/eurostat/databrowser/view/lfst_hhindws__custom_12782744/default/table

[16]. Eusostat. Part-time employment as percentage of the total employment, by sex and age (%). Link: https://ec.europa.eu/eurostat/databrowser/view/lfsa_eppga__custom_12861845/default/table

[17]. Garg, A. K., and Rijst, J., 2015. "The Benefits And Pitfalls Of Employees Working From Home: Study Of A Private Company In South Africa". Corporate Board: Role, Duties & Composition / Volume 11, Issue 2. Link: https://www.virtusinterpress.org/IMG/pdf/CB__Volume_11_Issue_2_2015_-3.pdf#page=34

[18]. Haas, M., and Mortensen, M., 2026. "The Secrets of Great Team Work", Harvard Business Review. Link: https://hbr.org/2016/06/the-secrets-of-great-teamwork

[19]. International Labor Organization (ILO). Output per hour worked (GDP constant 2017 international $ at PPP). Link: https://rshiny.ilo.org/dataexplorer7/?lang=en&id=GDP_2HRW_NOC_NB_A

[20]. Jerbashian, V., and Vilalta-Bufí, M., 2022. "Working From Home in European Countries Before and During The COVID-19 Pandemic". UB Economics Working Paper No. 427. Link: https://diposit.ub.edu/dspace/bitstream/2445/188574/1/E22-427_Jerbashian%2BVilalta.pdf

[21]. Kurdy, D.M., Al-Malkawi, H.-A.N. and Rizwan, S., 2023, "The impact of remote working on employee productivity during COVID-19 in the UAE:

the moderating role of job level". Journal of Business and Socio-economic Development, Vol. 3 No. 4, pp. 339-352. Link: https://doi.org/10.1108/JBSED-09-2022-0104

[22]. Marcus, J. S., 2022. "COVID-19 and the shift to remote work". Policy Contribution 09/2022, Bruegel. Link: https://www.bruegel.org/system/files/2023-06/PC%2009%202022.pdf

[23]. Monteiro, N. P., Straume, O. R., Valente, M., 2019. "Does Remote Work Improve or Impair Firm Labour Producti- vity? Longitudinal Evidence from Portugal". CESifo Working Paper No. 7991, Available at SSRN. Link: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3507262#

[24]. Nicole, F. C., 2015. "Gauging Perceived Benefits from 'Working from Home' as a Job Benefit". International Journal of Business and Economic Development Vol. 3 Number 3. Link: https://ijbed.org/cdn/article_file/content_80934_18-02-25-11-43-47.pdf

[25]. Pordata. Pessoal total e investigadores (ETI) em atividades de investigação e desenvolvimento (I&D).

[26]. Pordata. População com o ensino superior (ISCED 5-8) em % da população entre os 25 e os 64 anos: total e por grupo etário.

[27]. Pordata. População empregada: total e a tempo completo e parcial.

[28]. Pordata. Produtividade do trabalho por hora trabalhada (Euro).

[29]. Pordata. Remuneração dos empregados (Euro).

[30]. Pordata. Taxa de emprego, dos 15 aos 64 anos, por grupo etário – Homens.

[31]. Pordata. Valor acrescentado bruto: total e por setor de atividade económica (Euro).

[32]. Raj, R., Kumar, V., Sharma, N., Singh, S., Mahlawat, S., and Verma, P., 2023. "The study of remote working outcome and its influence on firm performance". Social Sciences & Humanities Open,Volume 8, Issue 1. Link: 10.1016/j.ssaho.2023.100528

[33]. Ravi, S. G., and Harrison, D. A., 2007. Pennsylvania State University. "The Good, the Bad, and the Unknown About Telecommuting: Meta- Analysis of Psychological Mediators and Individual Consequences". Journal of Applied Psychology 2007, Vol. 92, No. 6, 1524–1541. Link: https://www.apa.org/pubs/journals/releases/apl-9261524.pdf

[34]. Rupietta, K., and Beckmann, M., 2016. “Working from home: What is the effect on employees' effort?”. WWZ Working Paper, No. 2016/07, University of Basel, Center of Business and Economics (WWZ), Basel. Link: https://doi.org/10.5451/unibas-ep61317

[35]. Sostero, M., Milasi, S., Hurley, J., Fernandez-Macias, E. and Bisello, M., 2023. Published by Sciendo. “Teleworkability and the COVID-19 crisis: potential and actual prevalence of remote work across Europe”. IZA Journal of Labor Policy. Link: https://doi.org/10.2478/izajolp-2023-0006

[36]. World Bank. GDP per Capita (Current US$). Link:https://databank.worldbank.org/indicator/NY.GDP.PCAP.CD/1ff4a498/Popular-Indicators

[37]. World Bank. GNI per Capita (Current LCU). Link: https://databank.worldbank.org/source/world-development-indicators

[38]. World Bank. Gross Capital Formation (constant 2015 US$). Link: https://databank.worldbank.org/reports.aspx?source=2&series=NE.GDI.TOTL.KD&country=

[39]. World Bank. Gross Domestic Savings (Current LCU). Link: https://databank.worldbank.org/source/world-development-indicators

[40]. World Bank. Individuals using the internet (% of population). Link: https://databank.worldbank.org/source/world-development-indicators/Series/IT.NET.USER.ZS

[41]. World Bank. Trade (% of GDP).Link: https://databank.worldbank.org/reports.aspx?source=2&series=NE.TRD.GNFS.ZS&country=

[42]. World bank. Unemployment, total (% of total labor force). Link: https://databank.worldbank.org/reports.aspx?source=2&series=SL.UEM.TOTL.MA.ZS&country=

[43]. World Bank. Urban population (% of total population). Link: https://databank.worldbank.org/source/world-development-indicators/Series/SP.URB.TOTL.IN.ZS

7.1 Other References

[1]. Bargellini, S., and Biase, C. D., 2022. “Legal Update: Remote Work in Italy: Where Are We Now?”. Seyfarth. Link: https://www.seyfarth.com/news-insights/legal-update-remote-work-in-italy-where-are-we-now.html

[2]. Department of Business, Enterprise and Innovation, Ireland, 2020. "COVID-19 Supports for Business." Link: https://dbei.gov.ie/en/What-We-Do/Supports-for-SMEs/COVID-19-supports/

[3]. Enterprise Ireland, 2021. "Manufacturing and COVID-19: A Sectoral Response." Link: https://globalambition.ie/sectors/manufacturing/

[4]. Eurofound, 2022, “Telework in the EU: Regulatory frameworks and recent updates”, Publications Office of the European Union, Luxembourg. Link: https://www.eurofound.europa.eu/en/publications/2022/telework-eu-regulatory-frameworks-and-recent-updates

[5]. European Centre for Disease Prevention and Control, 2022. “Data on country response measures to COVID-19”. Link: https://www.ecdc.europa.eu/en/publications-data/download-data-response-measures-covid-19

[6]. European Comission, 2023. “2023 Country Report – Poland”. Link: https://economy-finance.ec.europa.eu/system/files/2023-06/ip245_en.pdf

[7]. European Comission. “Telework in the EU before and after the COVID-19: where we were, where we head to”. Link: https://joint-research-centre.ec.europa.eu/document/download/1ccf7717-ab52-4215-b14a-08d74e9d44fc_en

[8]. European Commission, 2020. "Denmark’s Economic Response to COVID-19."Link: https://commission.europa.eu/business-economy-euro/economic-recovery/recovery-and-resilience-facility/country-pages/denmarks-recovery-and-resilience-plan_en

[9]. European Commission, 2020. “Supporting jobs and economy during the coronavirus pandemic.” Link: https://ec.europa.eu/info/live-work-travel-eu/coronavirus-response/jobs-and-economy-during-coronavirus-pandemic_en

[10]. Eurostat. 2022, “Rise in EU population working from home”. Link: https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20221108-1

[11]. Finland's Working Hours Act (605/1996). Link:https://www.finlex.fi/en/laki/kaannokset/1996/en19960605_20100991.pdf

[12]. Idealista, 2022. "Working from home in Europe: Italy among the countries with the lowest percentage of remote workers". Link: https://www.idealista.it/en/news/lifestyle-in-italy/2022/07/21/144807-working-from-home-in-europe-italy-among-the-countries-with-the-lowest-percentage

[13]. McCarthy, A., University of Galway, "Working from home in Ireland". Link: https://stories.universityofgalway.ie/covid-19-working-from-home-in-ireland/index.html

[14]. McKinsey & Company, 2020. "The Future of Work in Europe." Link: https://www.mckinsey.com/featured-insights/future-of-work/the-future-of-work-in-europe

[15]. OCDE, 2024. "Raising investment to support growth in Latvia". Link: https://www.oecd.org/en/publications/raising-investment-to-support-growth-in-latvia_0ce0daed-en.html

[16]. OECD Library. "Flexible working arrangements in Hungary". Link: https://www.oecd-ilibrary.org/docserver/7f87b18e-en.pdf?expires=1723731538&id=id&accname=guest&checksum=784B2C1267544CA2328C1C321911A826

[17]. OECD Statistics, 2024. "Labour productivity amidst global uncertainties: Insights from 2022-23". Link: https://oecdstatistics.blog/2024/03/05/labour-productivity-amidst-global-uncertainties-insights-from-2022-23/

[18]. OECD, 2020. "Productivity Gains from Teleworking in the Post COVID-19 Era: How Can Public Policies Make It Happen?". Link: https://www.oecd.org/en/publications/productivity-gains-from-teleworking-in-the-post-covid-19-era_a5d52e99-en/full-report.html

[19]. POLITICO, 2020. "Europe's coronavirus lockdown measures compared". Link: https://www.politico.eu/article/europes-coronavirus-lockdown-measures-compared/

[20]. Sonali, 2023. "The Rise of Remote Work and Its Impact on Hiring in Finland". Link: https://inhuntworld.com/the-rise-of-remote-work-and-its-impact-on-hiring-in-finland/

[21]. Wolf, K., "How is remote work changing the workforce". CrossOver blog. Link: https://www.crossover.com/blog/how-is-remote-work-changing-the-workforce

[22]. Zoe Talent Solutions, 2023. “Remote Work Statistics Europe”. Link: https://zoetalentsolutions.com/remote-work-statistics-europe/

Appendix

Variables Meaning		
Model 1		
Variables	**Measurement**	**Source**
WFH	Percentage of employees usually working from home as a percentage of total employment	Eurostat
Productivity	Labor productivity per hour worked, in euros. (correponds to the ratio between GDP in euros at current prices in the calendar year and the number of hours worked in the calendar year)	Pordata
College	Total percentage of the population with a college degree as a % of the population between 25 and 64 years old	Pordata
Urban Population	People living in urban areas as defined by national statistical offices. The data are collected and smoothed by United Nations Population Division.	World Bank
1 Child	Number of adults between 18 and 64 years old, that are employed and have a child with less than 6 years	Eurostat
2 Children	Number of adults between 18 and 64 years old, that are employed and have two children with less than 6 years	Eurostat
3 or More Children	Number of adults between 18 and 64 years old, that are employed and have three children with less than 6 years	Eurostat
Income	Mean income in euros before social transfers	Eurostat
Living with a partner	Number of employed adults living in a couple	Eurostat
Model 2		
Variables	**Measurement**	**Source**

Productivity	Output per hour worked (GDP constant 2017 international $ at PPP)	ILO (International Labor Organization)
Workers involved in R&D	Total number of people employed in research and development activities	Pordata
Percentage Using Internet	Individuals using internet as a percentage of total population	World Bank
WFH	Percentage of employes persons usually working from home as a percentage of total employment	Eurostat
Share male workers	Share of male workers between 15 and 64 years old	Pordata
Average wage	Average remuneration that is paid to employees in euros	Pordata
Trade	Sum of exports and imports of goods and services measured as a share of gross domestic product.	World Bank
Gross capital formation	Gross capital formation (formerly gross domestic investment) consists of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories. Fixed assets include land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. Inventories are stocks of goods held by firms to meet temporary or unexpected fluctuations in production or sales, and "work in progress." According to the 2008 SNA, net acquisitions of valuables are also considered capital formation. Data are in constant 2015 prices, expressed in U.S. dollars.	World Bank
Employment	Total of employed persons in thousands	Pordata
Part time	Part-time employment as a percentage of total employment	Eurostat

Robustness tests		
Variables	**Measurement**	**Source**
Unemployment	Share of the labor force that is without work but available for and seeking employment.	World Bank
Gross domestic savings	Gross domestic savings are calculated as GDP less final consumption expenditure (total consumption). Data are in current local currency.	World Bank
Hourly productivity	Real labor productivity per hour worked (index 2015 = 100)	Eurostat
GNI per capita	Gross national income divided by midyear population. GNI (formerly GNP) is the sum of value added by all resident producers plus any product taxes (less subsidies) not included in the valuation of output plus net receipts of primary income (compensation of employees and property income) from abroad. Data are in current local currency.	World Bank
Gross value added	Wealth generated in production, subtracting the value of goods and services consumed to obtain it, measured in euros	Pordata
GDP per capita	Sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in current U.S. dollars. Dollar figures for GDP are converted from domestic currencies using single year official exchange rates. For a few countries where the official exchange rate does not reflect the rate effectively applied to actual foreign exchange transactions, an alternative conversion factor is used.	World bank