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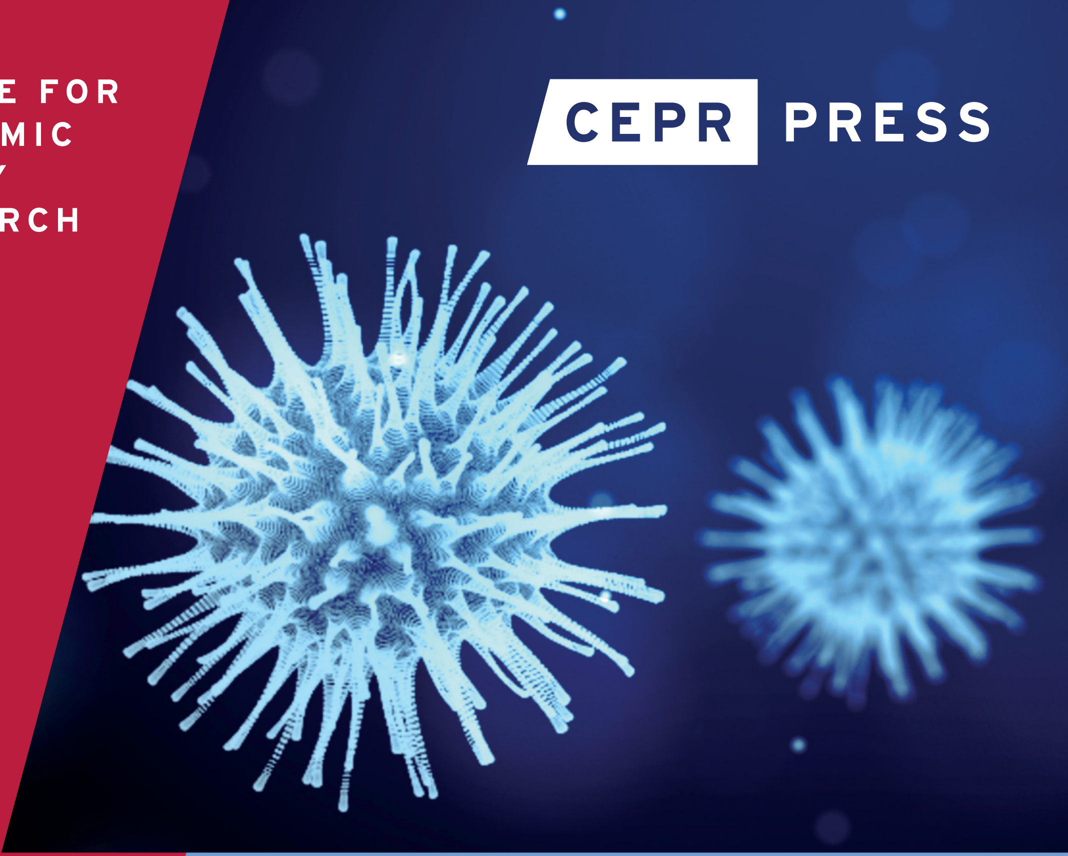

COVID ECONOMICS

VETTED AND REAL-TIME PAPERS

ISSUE 73
23 MARCH 2021

Covid Economics
Vetted and Real-Time Papers

Covid Economics, Vetted and Real-Time Papers, from CEPR, brings together formal investigations on the economic issues emanating from the Covid outbreak, based on explicit theory and/or empirical evidence, to improve the knowledge base.

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Ethics

Covid Economics will feature high quality analyses of economic aspects of the health crisis. However, the pandemic also raises a number of complex ethical issues. Economists tend to think about trade-offs, in this case lives vs. costs, patient selection at a time of scarcity, and more. In the spirit of academic freedom, neither the Editors of *Covid Economics* nor CEPR take a stand on these issues and therefore do not bear any responsibility for views expressed in the articles.

Submission to professional journals

The following journals have indicated that they will accept submissions of papers featured in *Covid Economics* because they are working papers. Most expect revised versions. This list will be updated regularly.

American Economic Journal, Applied Economics
American Economic Journal, Economic Policy
American Economic Journal, Macroeconomics
American Economic Journal, Microeconomics
American Economic Review
American Economic Review, Insights
American Journal of Health Economics
Canadian Journal of Economics
*Econometrica**
Economic Journal
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Journal of Public Finance and Public Choice
Journal of Political Economy
Journal of Population Economics
Quarterly Journal of Economics
*Review of Corporate Finance Studies**
Review of Economics and Statistics
*Review of Economic Studies**
Review of Financial Studies

(*) Must be a significantly revised and extended version of the paper featured in *Covid Economics*.

Covid Economics
Vetted and Real-Time Papers

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Fear of COVID and non-pharmaceutical interventions: An analysis of their economic impact among 29 advanced OECD countries[1]

Laurence Boone[2] and Colombe Ladreit[3]

Date submitted: 17 March 2021; Date accepted: 18 March 2021

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This paper analyses the economic effects of the COVID sanitary situation and non-pharmaceutical interventions (NPIs) on 29 advanced OECD countries. We use mobility data as a proxy for economic activity and compare the first wave of COVID to the second one. Overall, our results show that NPIs were the main explanatory factor behind the mobility reduction in advanced OECD countries during the first wave. The sanitary situation played a more important role during the second wave suggesting (i) a greater awareness of the severity of the health situation and/or (ii) an increase in individual responsibility, which was given more room as restrictions were less severe during the second wave. Focusing on 6 European countries in particular, we observe that those most affected during the first wave display higher elasticities to mobility restrictions, except for Italy where restrictions and the sanitary situation had similar impacts on mobility. Looking at the relative effects of different types of NPIs we see that more stringent measures had more impact on mobility. Nevertheless, we remain cautious regarding these last estimates as the rapid sequencing of NPIs likely implies issues of statistical identification.

1 This paper was written as part of the French national independent Mission on the assessment of the Covid-19 crisis management and on the anticipation of pandemic risks. We are grateful to Antoine Armand, Philippe Burnel, Balazs Égert, Jean Pisani-Ferry, Yvan Guillemette, Phillipe Martin, Romain Martischang, Pierre Parneix, Alexia Pastré, Didier Pittet, and Dave Turner for interesting discussions and valuable comments.

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Introduction

This paper aims to estimate the effects of non-pharmaceutical interventions (NPIs) and the COVID sanitary situation on the economy of advanced OECD countries, using Google mobility data as a proxy for economic activity. Our estimates attempt to shed light on four questions:

1- What is the average effect of NPIs, i.e. mobility restrictions, and individual perceptions of the sanitary situation on mobility?
2- Are the elasticities of economic activity to mobility restrictions different between the first and the second wave?
3- Are these elasticities different between countries, in particular between France, Germany, Italy, Spain, the United Kingdom, and Switzerland?
4- What are the relative effects of different types of NPIs?

Overall, we find that restrictions affected mobility in advanced OECD economies much more than fears of COVID infection. This effect is more visible during the first wave than during the second as the influence of the sanitary situation gained weight during the second wave. This is probably due to (i) a second wave stronger than the first in many countries, (ii) while NPIs were, on average, less stringent during the second wave, leaving more room for voluntary social distancing. An analysis by country shows that the most affected countries during the first wave display higher elasticities to mobility restrictions, except for Italy where restrictions and the sanitary situation had similar impacts on mobility. Looking at the relative effects of different types of NPIs we see that more stringent measures had more impact on mobility. Nevertheless, we remain cautious regarding these last estimates as the rapid implementation in the sequence of NPIs likely implies issues of statistical identification.

Our work echoes many publications on COVID, we will only mention a few here. Overall, studies have shown that both mobility restrictions and fears of infections lead people to reduce their activity. Thus Demirgüç-Kunt, Lokshin, and Torre (2020) show that stricter lockdowns are associated with more important falls in economic activity. Looking at the U.S., Gupta et al. (2020) find that individuals primarily adjusted their mobility voluntarily as the sanitary situation deteriorated, but the introduction of restrictions at the local level further reduced it. Égert et al. (2020) and the IMF (2020) also use mobility as a proxy for economic activity and show that containment measures, as well as a degraded sanitary situation, are associated with significant economic costs. However, our results differ slightly from the IMF's which finds, on a comparable

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sample of advanced countries, that NPIs and the sanitary situation had an equivalent influence on the decline in mobility during the first wave[1]. Our results suggest that NPIs played a more important role in the decrease in economic activity than voluntary distancing. The difference comes from a different treatment of daily deaths, the variable used to estimate the elasticity of voluntary social distancing. Indeed, the IMF (2020) uses the logarithm of the daily death toll as an independent variable while our analysis uses the daily death toll per 1 million, as in Égert et al. (2020). Using the logarithm assumes that people are responding to changes in the death toll and implies that people understand the exponential dynamics of the epidemic. Instead, we assume that people react to daily announcements. There is no evidence that one hypothesis is superior to the other and we should note that this variable also captures other effects linked to the perception of crisis management.

In parallel, country-level studies have found that mobility or consumption reductions are mainly caused by fears of infections and voluntary social distancing. Thus Andersen et al. (2020) use data from bank card transactions to show that the decline in consumption in Sweden was almost equivalent to that in Denmark despite much lower restrictions on movement. Goolsbee and Syverson (2020) find that individuals in the U.S. reduced their movements voluntarily rather than as a reaction to the implementation of lockdowns. These results remain compatible with ours. They suggest that in the absence of restrictions people adjust their behaviour, and underline the existence of cultural differences between countries, which have also been highlighted by other studies (Bargain and Aminjonov 2020; Brouard 2020). Indeed, our estimates apply to the average of advanced OECD countries, behind which some country heterogeneity exists and on which we shed some light. Besides, our estimates for the second wave show that the sanitary situation plays a greater role. This suggests that when NPIs are less stringent the perception of the sanitary situation on mobility gains weigh. Another interpretation could be that there is a learning curve according to which behaviours adapt in face of the virus. Overall, our results are in line with the idea, advanced for example by Chetty et al. (2020), that addressing the health concerns themselves is a pre-requisite for the resumption of mobility, and therefore for an economic recovery.

Our paper is structured as follows: in section 1 we describe the data used and the methodological framework, section 2 presents the average elasticity associated with NPIs and voluntary social

[1] In fact, the IMF finds that voluntary social distancing has a slightly higher effect than NPIs on mobility among advanced economies. See Figure 2.2.3 in IMF (2020).

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distancing in advanced OECD economies, section 3 compares estimates for six European countries, and section 4 evaluates which NPIs appear to be more effective at reducing mobility.

I- Data and methodological framework

Our analysis relies on variables that are measured at a daily frequency, and available for a sample of 29 advanced OECD countries[2], to estimate the impact of both government restrictions and the health situation:

- *Mobility*, published by Google, is used as a proxy for economic activity. This measure has the advantage of being available at high frequency (daily), very quickly (the data is published a few days after being recorded by Google), and for a large number of countries. Its strong correlation with economic activity (see Figure 1) makes it a credible instrument for estimating economic activity. Over the first three semesters of 2020, the variations in mobility and the GDP forecast errors correlate at 59% for advanced OECD countries. This measure has been widely used since the start of the crisis by national statistical institutes (INSEE, ONS), international organisations (IMF, 2020; Égert et al. 2020; Chen et al. 2020; Maloney and Taskin 2020), and in academic studies (Chernozhukov et al. 2020; Bargain and Aminjonov 2020; Barbieri and Bonini 2020). INSEE, the French national statistical authority, shows a particularly strong correlation between residential mobility, i.e. the increase in time spent at home, and the fall in economic activity compared to a normal situation in France (see Figure A1).

  Google provides mobility data on travels to specific places, including workplaces, retail and recreational places, transit stations, groceries and pharmacies, parks, and residences. The data they publish is the change in mobility in percentage between one day and its baseline value. This baseline is the median value of the same day of the week over the 3rd January to 6th February 2020 period, at which time the pandemic was not proven elsewhere than in China.

  There are limitations to this measure. In particular, this variable measures the mobility of Google Maps users who have authorised Google to track their movements. It is therefore likely that parts of the population are not represented in these data.

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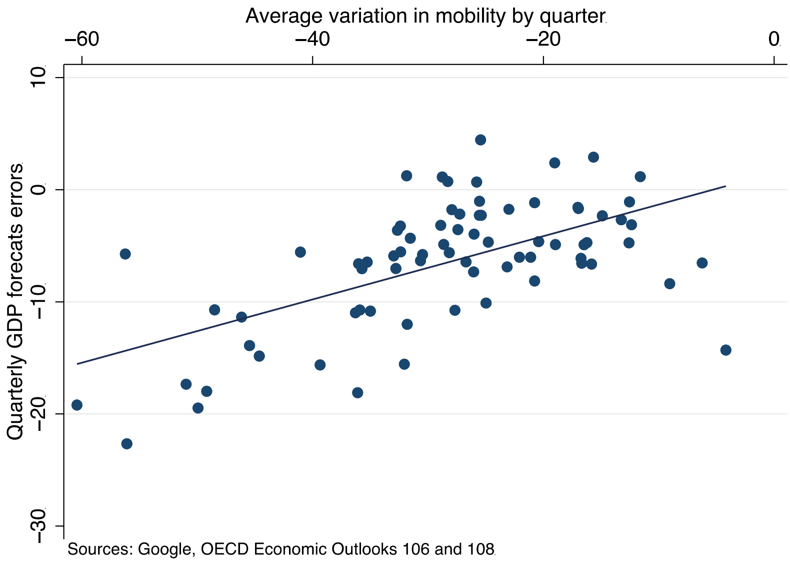
[2] The 29 countries are Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Ireland, Israel, Italy, Japan, Latvia, Lithuania, Luxembourg, New Zealand, Norway, Netherlands, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, the United Kingdom, and the United States.

Figure 1: Correlation between the changes in mobility measured by Google and the GDP forecast errors among the 29 advanced OECD countries selected



Note: Estimates for the first three quarters of 2020. The average variation in mobility during the quarter is calculated compared to the period from January 3 to February 6, 2020. Mobility is the arithmetic mean of mobility in the workplace, in retail and leisure businesses, in transit stations

- *The Oxford Stringency Index* is an aggregate measure of the level of stringency of the NPIs implemented in a country. It is published by the University of Oxford and available at a daily frequency for a large number of countries.

  This index is calculated according to the following steps. First, the type of NPI implemented is classified into one of eight categories defined by the University of Oxford: school closure, workplace closure, cancellation of public events, restrictions on gatherings, closure of public transport, stay-at-home requirements, restrictions on internal movement, and international travel controls. Once categorised, a score ranging from 1 to 3 (or 1 to 4) is assigned to the NPI depending on the severity of the measure. Table A1 synthesises the different scores and their meanings for each type of NPI.

  Secondly, a sub-index from 0 to 100 is calculated for each category of NPI. Thus, if a school closing of level 2, out of 3, has been implemented in a country, a sub-index of 66 is assigned to the corresponding days (2/3*100). In the case of a regional or sectoral measure, as opposed to a national measure, a scalar of 0.5 is subtracted from the score.

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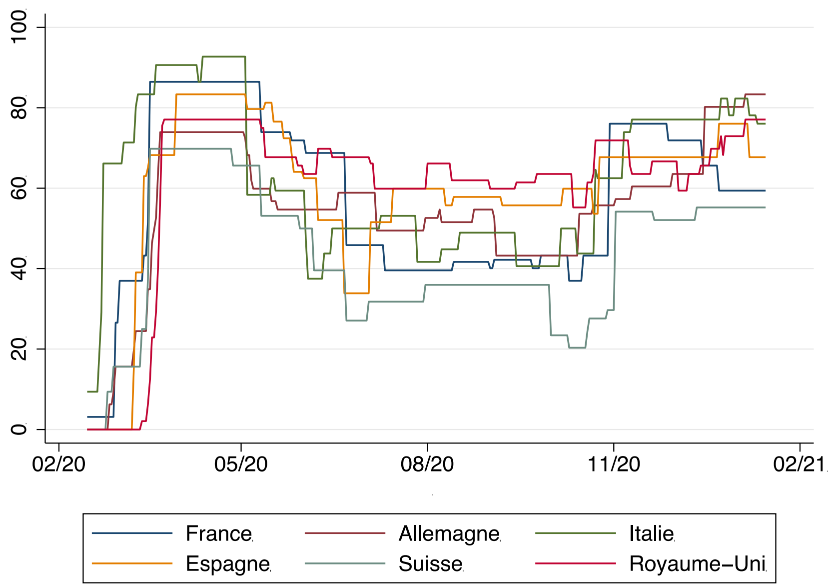
The overall stringency index is then calculated as the arithmetic mean of the eight sub-indices[3,4].

This index makes it possible to synthesise a lot of information simply: an index that is close to 100 means that many high-intensity NPIs have been implemented, and therefore that mobility restrictions are significant. Conversely, an index equal to 0 means that there are no restrictions. Figure 2 shows the evolution of the average index over time in France, Germany, Italy, Spain, Switzerland, and the United Kingdom. We can see that NPIs increased since mid-February 2020 in these 6 countries, although unevenly, and started to be lifted in May. New restrictions were then put in place from November 2020.

Figure 2: Trends in the Oxford stringency index in France, Germany, Italy, Spain, Switzerland, and the United Kingdom from Feb 15, 2020, to Jan 15, 2021



[3] The "official" Oxford stringency index is the average of these 8 indices of containment measures plus one index that synthesises the implementation of a public health campaign on COVID. As in IMF (2020), we focus on the 8 indices of containment measures and exclude the index of public health campaigns. Indeed, we include a second independent variable on daily COVID deaths which should capture the reaction to the sanitary situation. Excluding the public health campaign index is therefore necessary to avoid collinearity. Nevertheless, as a robustness check we also run our analysis using the "official" Oxford stringency index and our results remain unchanged.

[4] For more information see Hale et al. (2020).

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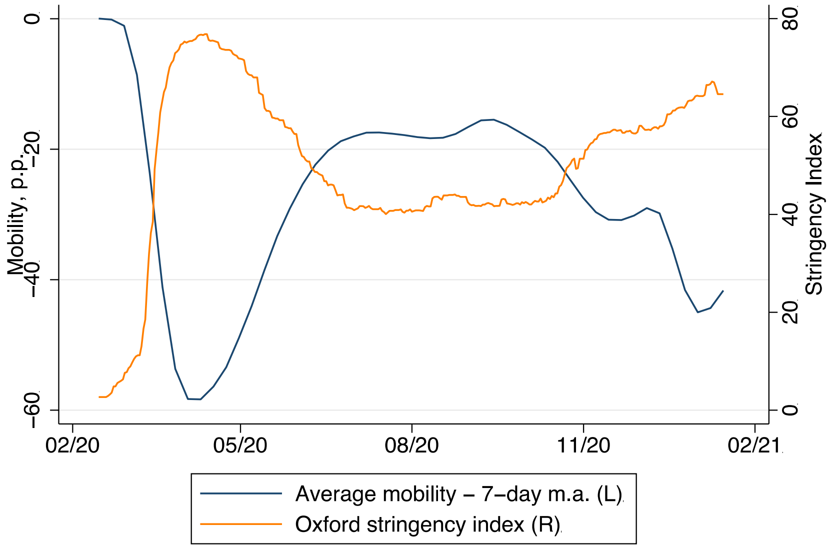
Like any synthetic index, certain country differences in the implementation of NPIs are not taken into account. Thus, a scoring scale from 1 to 3, or 1 to 4, does not capture certain specificities that differentiate two NPIs of the same score in two different countries. Despite these drawbacks, the correlation between mobility and the aggregate stringency index is apparent and shows that individuals strongly decrease their mobility as a result of the adoption of NPIs (see Figure 3).

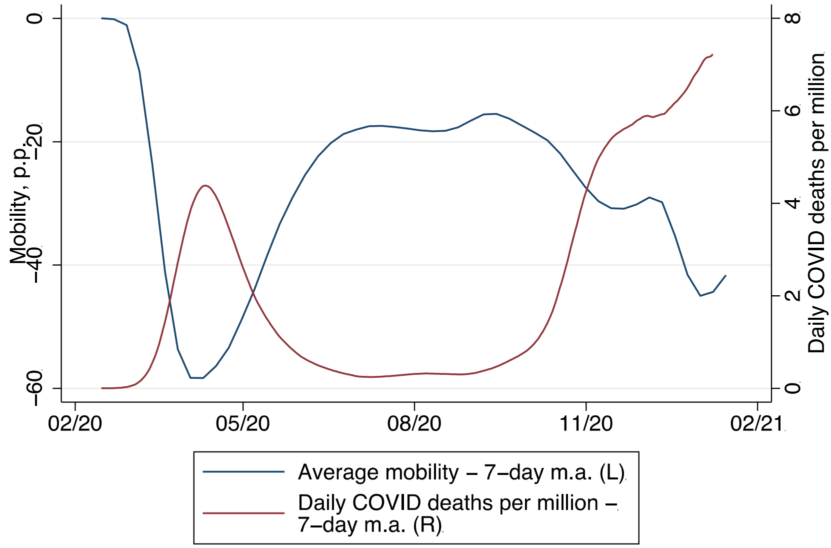
Figure 3: Average change in the Oxford stringency index and mobility in advanced OECD countries studied from Feb 15, 2020, to Jan 15, 2021



- Finally, the daily number of confirmed COVID deaths, as a share of one million inhabitants, is used to control for the sanitary situation of a country. We use data from the University of Johns Hopkins and interpret this variable's coefficient as a measure of the fear or awareness of the sanitary situation in the country and its ensuing voluntary social distancing. Figure 4 shows that mobility tends to decline when daily deaths increase, suggesting that mobility does not only react to government interventions. Conversely, the improvement in the sanitary situation that took place in the 3rd quarter of 2020 was parallel to a rapid recovery in mobility.

  It is important to note that the reality of the sanitary situation and the death toll are better approximated by the excess mortality over the period. Nevertheless, it can only be calculated a posteriori and does not reflect the state of knowledge at the time. Therefore, daily COVID deaths seem a better way to measure individuals' reactions to the reality presented to them at time t.

Figure 4: Average daily COVID deaths and mobility in advanced OECD countries from Feb 15, 2020, to Jan 15, 2021



From these data, OLS panel regressions are estimated on our sample of 29 advanced OECD countries on a period that spans from February 15, 2020, to January 15, 2021. We then divide the data into two sub-periods, to compare the first wave (whose period is defined here as February 15, 2020, to June 30, 2020) to the second wave (September 1, 2020, to January 15, 2021). Using daily frequency data enables us to have approximately 9,700 observations for the entire period. We choose to focus on advanced OECD countries to have a sample of countries homogenous in their characteristics that are not linked to the pandemic.

II- Average impact of NPIs and daily COVID deaths on mobility in advanced OECD countries

In this section, we present estimates of the effects of containment measures and voluntary social distancing on mobility across our sample of 29 advanced OECD countries.

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a. Specification

A first analysis consists of estimating the elasticity of mobility to the adoption of NPIs, and daily COVID deaths using the following panel equation:

$$Mobility_{i,t} = c + \alpha_i + \tau_t + \beta * Stringency_{i,t} + \gamma * Deaths_{i,t-1} + \varepsilon_{i,t} \quad (1)$$

Where:

- $Mobility_{i,t}$ is the change in mobility as measured by Google in country i at time t
- $Stringency_{i,t}$ is the average stringency level of the containment measures in country i at time t
- $Deaths_{i,t-1}$ is the seven-day rolling average of the daily number of confirmed COVID deaths per million people in country i at time t-1[5]
- α_i and τ_t are country and time fixed effects
- c is a constant
- Standard errors $\varepsilon_{i,t}$ are aggregated at country and weekly level[6]

We estimate two coefficients of interest from Equation 1:

1- β, which is the elasticity of mobility to the adoption of NPIs. It measures how much individuals adjust their mobility following the implementation of containment measures.

2- γ, which corresponds to the elasticity of mobility to daily deaths and which we interpret as the voluntary adjustment of individual mobility to the sanitary situation of the country and the level of fear associated with it.

We use country-fixed effects to absorb the effect of certain country specificities on mobility, which could be institutional or cultural. Similarly, time fixed effects enable us to capture common effects across countries for specific dates. For example, they control for specific variations in mobility on Christmas Day or the evolution of the global sanitary situation.

[5] National values for the number of deaths are used here. In order to test the robustness of our results, we estimated the same equation including the global daily number of deaths in order to take into account the possible impact of an epidemic rise in the rest of the world on the mobility of a country. Our results remain unchanged with the inclusion of this variable (the time fixed effects already capture part of this dynamic).

[6] Our results are robust to clustering at the country level only.

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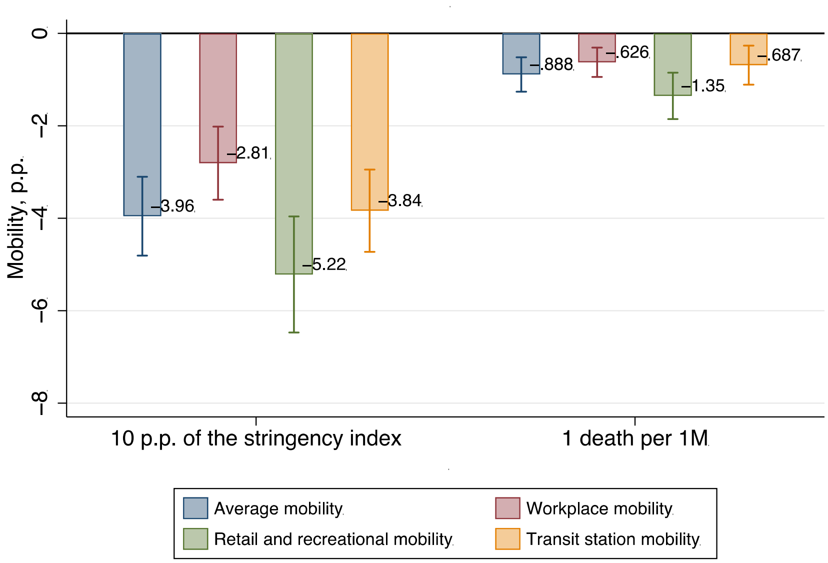
Finally, we aggregate our standard errors at the country and week level to take into account correlation effects within a country and/or during the same week.

b. Results

Figure 5 displays our results for Equation 1 using the whole sample, that is on the period that spans from February 15, 2020, to January 15, 2021. We look at four estimates of mobility across our 29 countries: mobility in workplaces, in retail and recreational places, in transit stations, and an average of the previous three types of mobility.

Figure 5: Impact of an increase of 10 p.p. of the stringency index and 1 death per 1M on mobility among advanced OECD countries



Note: 95% confidence interval. Detailed regression results available in the appendix, Table A2.

The results are consistent with the general intuition, in the context of an overall decrease in mobility. Thus, we observe that a 10 percentage point (p.p.) increase in the stringency index is associated with a decrease in average mobility of 4 p.p. In parallel an increase in daily COVID deaths of one for a million is associated with a decrease in mobility close to 0.9 p.p. These effects are quite large when compared to the variables' standard deviations over the period – February 15, 2020, to January 15, 2021 – which are 24% for the stringency index and 4 for daily COVID deaths per million. It is also interesting to see that the decline in mobility is greatest in retail and recreational businesses, followed by mobility in transport and mobility in the workplace. It shows that non-essential travels have decreased the most.

Equation 1 is then re-estimated over two different periods: the first wave period which spans from February 15, 2020, to June 30, 2020, and the second wave period, from September 1, 2020, to January 15, 2021. Figure 6 shows that the elasticity of NPIs does not change much between the first and the second wave and remains stable between -4.65 and -4.18 for a 10 p.p. increase in the stringency index. Conversely the elasticity of daily COVID deaths increases (in absolute value): while COVID deaths do not have a significant effect on mobility in the first wave, the coefficient becomes significant in the second wave, with an elasticity of -1.12. This suggests greater awareness of the pandemic during the second wave and means that the effect of deaths represented in Figure 5 is driven by data from the second wave. A breakdown by type of mobility shows that this difference is particularly visible for mobility in retail and recreational businesses and transport (see Figure 7), in line with our previous interpretation. Besides, we see that while the elasticities of NPIs in retail and transport do not change much from the first to the second wave, this is not the case for mobility at work. Indeed, the decline in mobility at work is less significant during the second wave, which is consistent with the idea that containment measures were less severe on workers during the second wave[7].

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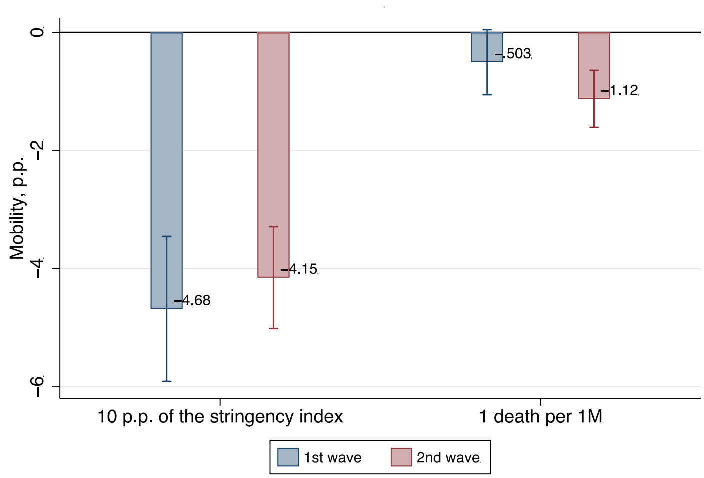
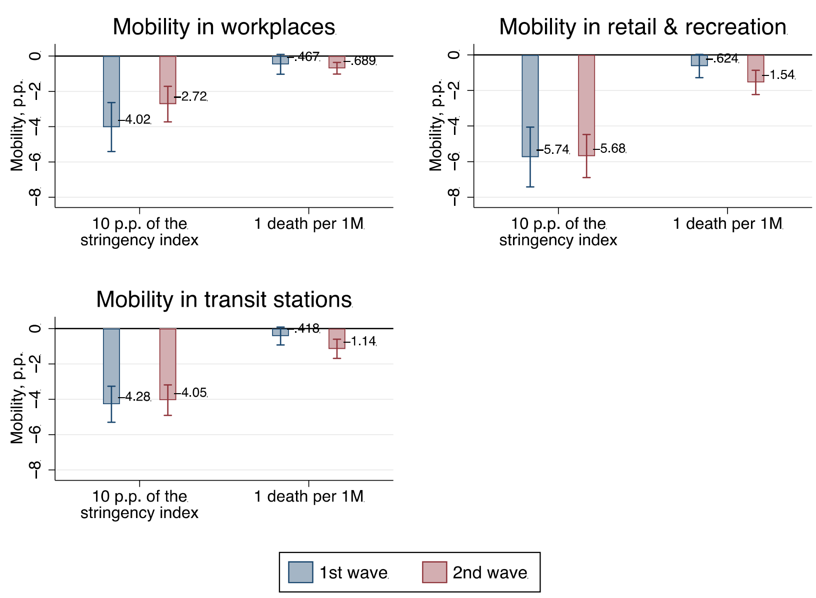
[7] Note that this analysis ends on January 15, 2021, date at which the second wave is not finished. Workplace restrictions may become more severe in the following weeks or months.

Figure 6: Evolution of the elasticities of the stringency index and daily COVID deaths between the first and second waves for advanced OECD countries



Note: 95% confidence interval. Detailed regression results available in the appendix, Tables A3 and A4.

Figure 7: Evolution of the elasticities of the stringency index and daily COVID deaths between the first and second waves for advanced OECD countries, by type of mobility



Note: 95% confidence interval. Detailed regression results available in appendix Tables A3 and A4.

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III- Differential effects according to the country

We now turn to an analysis by country and compare the evolution of mobility in six European countries: France, Germany, Italy, Spain, Switzerland, and the United Kingdom. We show that countries react differently to the sanitary situation and the implementation of mobility restrictions.

Figures 8 and 9 display show the evolution of mobility, stringency index, and COVID deaths over time for each of these countries. We see that during the first wave mobility fell in all countries and did not return to its pre-crisis level afterwards. In particular, the more severe the restrictions, the more important the decline in mobility was. Those were also accompanied by important mortality peaks (France, Italy, Spain, and the United Kingdom). Germany and Switzerland are characterized by drops in mobility that are smaller than in other countries. This is consistent with lower death numbers and a lower stringency index as these two countries have been less affected by the first wave.

During the summer of 2020, mobility rebounded in all countries as NPIs were lifted. However, the United Kingdom stood out from other countries as mobility picked up more slowly and stabilised at a lower level than the other countries. This is due to a more limited lifting of NPIs and could also be linked to a less precise estimation of the Oxford stringency index there, as England, Wales, Scotland, and Northern Ireland had different policies in place[8].

Dynamics during the second wave were less homogeneous among countries. Spain faced a relatively linear rise in COVID deaths during the summer, accompanied by an increase in NPIs from July which did not result in any visible change in mobility. France and the United Kingdom experienced a significant increase in the number of daily COVID deaths in September. This increase quickly became exponential and was followed, in France, by the implementation of additional NPIs. In parallel, the United Kingdom adopted additional NPIs that were less strict than in France, as they were already at a high level of restrictions. Consequently, mobility in the United Kingdom decreased less than in France, having also stabilised at a relatively low level during the summer. However, after stabilising in November-December, the death toll increased exponentially in the United Kingdom from the end of December, probably because of the emergence of the new variant. It was followed by a sharp increase in restrictive measures and a

[8] Overall, restrictive measures taken at the regional level increased between Wave 1 and Wave 2 but remain proportionately low. Indeed, they represent 4% of our sample during the first wave against 6.3% during the second. However, in the United Kingdom the proportion of regional measures increases from 5.7% to 11.6%. The Oxford team notably dedicated a specific research paper to this question, with England, Scotland, Wales and Northern Ireland having more diverged in their management of the health situation during the second vague (see Cameron-Blake et al. 2020).

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marked drop in mobility. Italy followed a development similar to France's, with a lag, as its second wave started at the end of October. Its second wave nevertheless appears to be as deadly as the first, although under-testing was probably an issue during the first wave. Switzerland, relatively spared by the first wave, saw a sudden and brutal increase in its daily death toll. However, mobility did not react much to it, reflecting fewer restrictions. It then decreased with some delay compared to the observed sanitary situation. The same delay was observed for the decrease in the number of deaths and mobility in January. Finally, Germany was hit by a second wave of COVID relatively late in 2020 compared to the other countries. However, the increase in the daily death toll became significant quite rapidly. As of January 15, 2021, the peak of daily deaths did not appear to have been reached. Greater mobility restrictions than in the first wave were put in place. Mobility fell in parallel to these restrictions and the abrupt deterioration of the health situation.

<u>Figure 8</u>: Evolution of mobility and the stringency index among six selected European countries

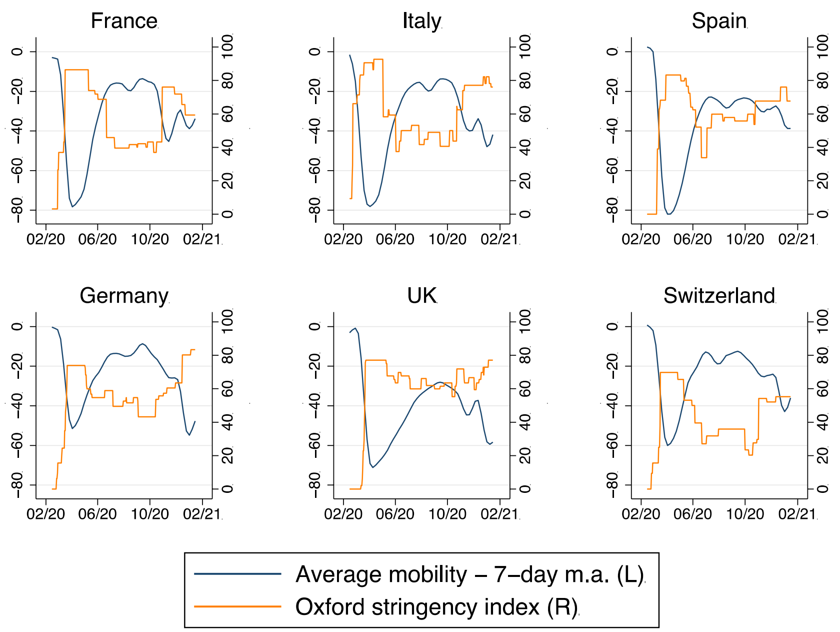
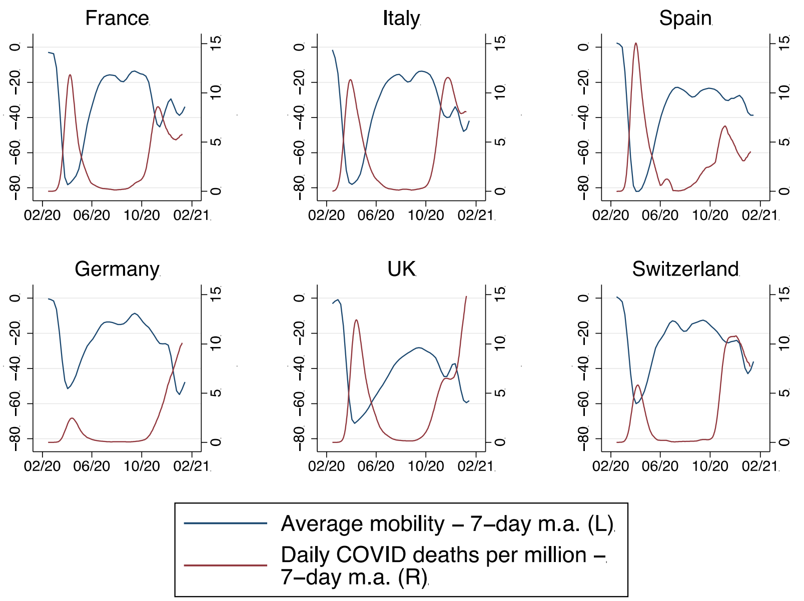


Figure 9: Evolution of mobility and the daily COVID deaths per million among six selected European countries



a. Specification

To quantify these country differences, we estimate the same equation as in part I and add two elements to capture each country's differential impact:

$$Mobility_{i,t} = c + \alpha_i + \tau_t + \beta_1 * Stringency_{i,t} + \gamma_1 * Deaths_{i,t-1} + \beta_2 * CountryDummy_i * Stringency_{i,t} + \gamma_2 * CountryDummy_i * Deaths_{i,t-1} + \varepsilon_{i,t} \qquad (2)$$

Where $CountryDummy = 1$ if country i is France, Germany, Italy, Spain, Switzerland, or the United Kingdom. Equation 2 is therefore estimated six times, and the coefficients of each estimation are compared to each other.

The coefficients β_2 and γ_2 make it possible to estimate the differential impact of, respectively, the increase in NPIs and the number of daily COVID deaths in country i compared to the average of advanced OECD countries. The sum of the coefficients β_1 and β_2 can be seen as an estimate of the average impact of an increase in the stringency index in the country for which

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$CountryDummy_i$= 1, and the sum of the coefficients γ_1 and γ_2 as that of the average impact of an increase in the daily death toll in the same country.

One should note that as we use different country dummies for each estimation, therefore the coefficients β_1 and γ_1 do not represent the same average of countries each time. In other words, when $CountryDummy_i$= 1 and country i is France, the coefficients β_1 and γ_1 are averages for our sample of OECD countries minus France. This implies that our coefficients β_2 and γ_2 must be interpreted as the differential effects in country i compared to the advanced OECD countries minus country i. Nevertheless, the relative stability of the coefficients β_1 and γ_1 over the six regressions (see Tables A5 and A6) makes us believe that the approximation proposed in the previous paragraph is acceptable[9].

b. Results

First wave

Figure 10 shows the effects associated with an increase of 10 p.p. in the stringency index and of 1 death per million for each country during the first wave.

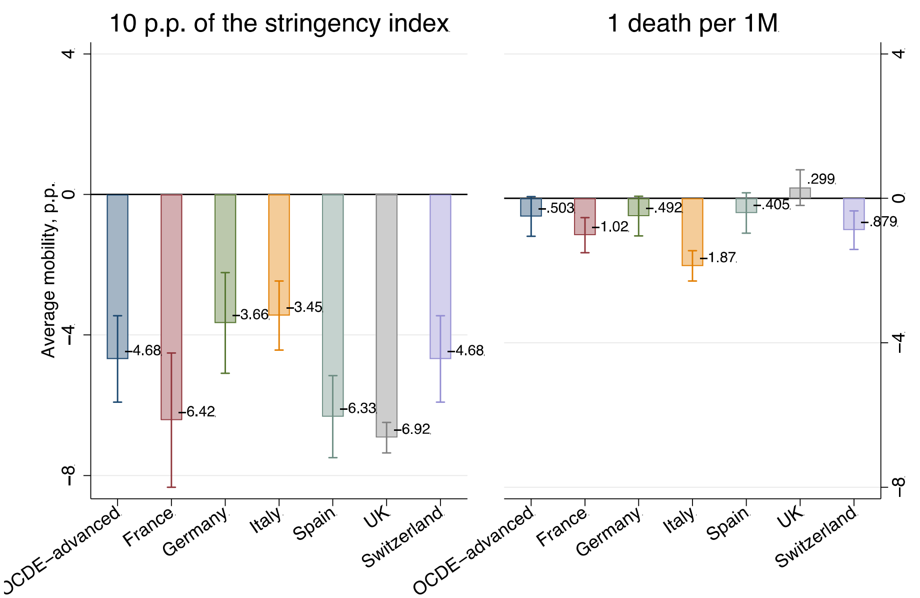
- We can see that France, Spain, and the United Kingdom reacted in a similarly strong fashion to the implementation of NPIs. Conversely, Germany and Italy have coefficients that are below the average of advanced OECD countries. Finally, Switzerland is in line with the average.
- The elasticity of NPIs differs from country to country and tends to be greater in the countries most affected by the first wave of COVID.
- Switzerland and France display larger elasticities to daily deaths than the average, but less so than Italy. Germany, Spain, and the United Kingdom have non-significant elasticities. In these three countries, mobility appears to be affected only through NPIs.
- The case of Italy is particularly interesting. While its elasticity to NPIs is lower than the average for OECD countries, the elasticity to daily deaths is particularly high: it is more than three times the average elasticity of advanced OECD countries (although that the latter is only significant at 10%). This is probably due to Italy being

[9] We also perform a robustness check where we the interactions of the 6 countries are included at the same time in our equation. The country estimates in Figures 10 and 11 remain unchanged, but our aggregate for advanced OECD countries minus these 6 countries is no longer significant. This implies that the inclusion of these 6 countries (together) for the analysis of the average of advanced OECD countries is important.

the first European country affected by the pandemic. Several weeks separated the identification of the first epidemic outbreaks and the adoption of a national lockdown, and those weeks were marked by a strong sense of panic. Consequently, mobility had already fallen before the most drastic NPIs were adopted (see Figure A2).

- This suggests that isolating the effects of voluntary distancing from government interventions might be difficult as they tend to occur at the same time. It is, therefore, necessary to interpret our results as correlations and associations rather than causal relations.

Figure 10: Effect of the NPIs and daily COVID deaths on mobility, by country, during the first wave



Note: 95% confidence interval. Detailed regression results available in the appendix, Table A5.

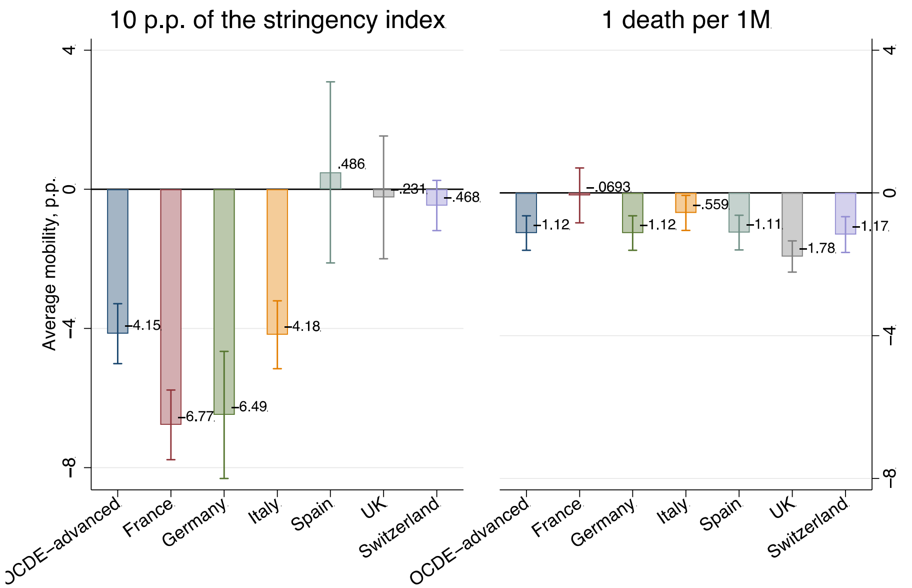
Second wave

Figure 11 presents the effects associated with a 10 p.p. increase in the Oxford stringency index and an increase of 1 death per million for each country during the second wave.

- France and Germany are now the two countries with the highest elasticities to NPIs. The elasticity of France is similar to that observed in the first wave, a sign that people have reacted similarly to government-imposed restrictions. Conversely, Germany now has a higher coefficient, which means that individuals adjusted more their mobility to the restrictions than in the first wave, consistent with a more important wave than in the first episode.
- Italy falls within the average of advanced OECD countries while Spain, the United Kingdom, and Switzerland have non-significant coefficients. Spain and the United Kingdom's results may be due, in part, to more numerous and different regional restrictions, whose measurement by the stringency index is less precise. The results in Switzerland seem to reflect the subdued reaction of mobility following the implementation of restrictive measures during the second wave. It also suggests that fears of infections played a bigger role and that mobility reacted more to death figures (see Figure 8).
- The elasticities to daily deaths are, overall, greater than during the first wave. France and Italy stand out with an elasticity that is not significant and lower than the average of advanced OECD countries. These results are particularly striking as these two countries were the only ones with greater than average elasticities in the first wave. They can suggest two things. First, that these two countries implemented restrictions earlier than in the first wave, before a rapid rise in daily deaths. Thus, the majority of the effects of the decrease in mobility are captured by the coefficient on the stringency index. Second, it can also reflect that individuals have grown used to the health situation, and do not display the same sense of panic as during the first wave.
- Germany, Spain, and Switzerland have elasticities on daily deaths that are in line with the average of advanced OECD countries. Yet, their elasticities are greater than during the first wave, a sign that individuals adjusted more their movements according to the sanitary situation. This is consistent with our descriptive evidence for Germany and Switzerland where the second wave was much stronger.

- Finally, the United Kingdom shows an elasticity to daily deaths that is above average and larger than during the first wave. This could reflect a particularly deteriorated sanitary situation during the second wave.
- Overall, these results suggest that the sanitary situation had more of an effect on mobility in the second wave (in 4 of the 6 countries examined here) while at the same time, the reaction to NPIs was less homogeneous among countries.

Figure 11: Effect of the NPIs and daily COVID deaths on mobility, by country, during the second wave



Note: 95% confidence interval. Detailed regression results available in the appendix, Table A6.

To better compare the associated effect of NPIs on mobility with that of daily deaths, we x-standardise the coefficients estimated above. In other words, each coefficient is multiplied by the standard deviation of its variable for country i. These standardised coefficients allow to visualise the weight of each independent variable on mobility during the first wave (Figure 12) and the second (Figure 13) for each country.

Three observations can be made from Figures 12 and 13:

- The standardised coefficients of the stringency index are larger in the first wave than the second for all countries. This reflects a second wave of NPIs that is less strict than the first. Thus, if the elasticities associated with the stringency index for the average of advanced OECD countries are very close between the first and the second wave (with respective values of - 4.68 and - 4.15, see Figure 6), the standardised coefficients are different. It is -12 p.p. in the first wave and -8 p.p. in the second on average for OECD advanced economies. The standard deviation of the stringency index is lower during the second wave, which is consistent with the fact that most restrictions remained during the first and second waves. Meanwhile, the standardised coefficients of daily deaths gained more explanatory weight on the mobility decrease in the second wave. When looking at the average of advanced OECD countries, daily deaths correspond to 16% of the effect of NPIs during the first wave and nearly 75% during the second wave. This is due to both a higher elasticity and a higher standard deviation of daily deaths in the second wave on aggregate (see Figures 10 and 11 for the evolution of the elasticity). However, results by countries detailed below show some heterogeneity across countries.

- In the first wave, the greater effect of restrictions on mobility relative to daily deaths is visible in each country selected. Only Italy stands out from the other countries: its standardised coefficients for NPIs and daily deaths are equal (see below). This suggests that the sanitary situation weighed as heavily as the mobility restrictions on Italy's decrease in mobility during the first wave. Conversely, in the United Kingdom, Spain, and Germany the daily number of deaths had almost no effect on mobility in the first wave (the positive effect in the case of the United Kingdom is not significant), as suggested by their non-significant elasticities. Switzerland, whose elasticity is significantly different from zero, nevertheless has a very low standardised coefficient. This indicates that daily variations in deaths were low during the first wave in Switzerland. In France, even if the sanitary situation did have a significant effect on mobility, NPIs have about 5 times more impact on mobility. France's sharp decrease in mobility during the first wave is therefore mainly linked to the implementation of restrictions on movements.
- In the second wave, all the countries studied display lower standardised coefficients on NPIs than their first wave's, and in the case of Germany an equal one. This reflects, as highlighted above, mobility restrictions that are, on average, less stringent during the second wave. Nonetheless, as this sample end on January 15, 2021, it is possible that Germany and the United Kingdom reach higher levels of restrictions in the rest of their second wave. In a context of uncertainty around new COVID

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variants, restrictions in the second wave might exceed that of the first for some countries in the future. At the same time, countries that suffered from a second wave larger than the first - Germany, the United Kingdom, and Switzerland - saw an increase in their standardised coefficient of the number of daily deaths. Spain has standardised coefficients close to zero, which reflect its limited variations in mobility during the second wave, as well as a second wave peak well below the first one. In Italy, the effect of daily deaths is less important during the second wave. As explained above, the climate of anxiety that was present during the first wave might have eased. A similar interpretation can be made to explain the lack of effect of daily deaths on mobility in France, which comes from a non-significant elasticity. Thus, people might have reacted less to the deterioration of the sanitary situation in these countries during the second wave. This is perhaps due to the communication around these deaths that became less vocal or to increased confidence in the effectiveness of individual protective measures, such as masks or hand washing.

Figure 12: Standardised coefficients of NPIs and COVID deaths on mobility, by country, during the first wave

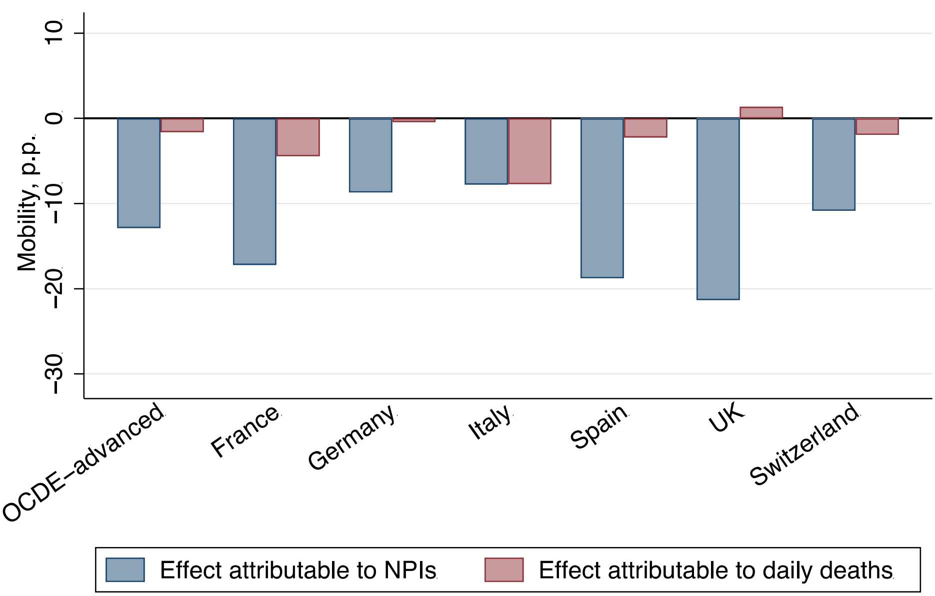

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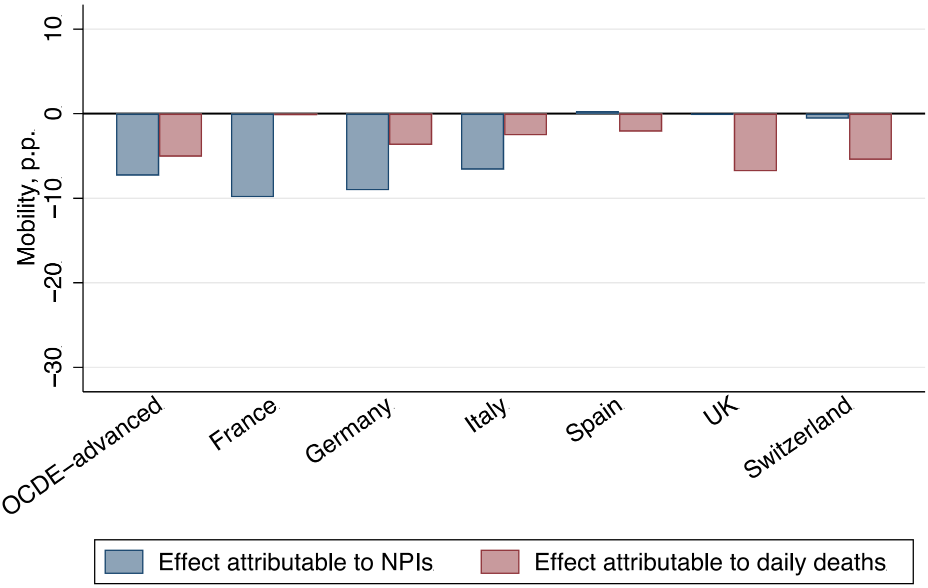
Figure 13: Standardised coefficients of NPIs and COVID deaths on mobility, by country, during the second wave



IV- Effects of different NPI categories on mobility

a. Specification

The differences in elasticities according to the country suggest that the composition of NPIs behind the increase in the stringency index may matter. Hence, the type of NPI, as well as the degree of severity of the measures, could have different effects. To explore these alternatives, we estimate two other equations.

A first equation (Equation 3) breaks down the Oxford stringency index in its eight sub-indices (see Table A1). This makes it possible to compare, for example, the impact of the closure of schools on mobility to the implementation of restrictions on gatherings.

$$Mobility_{i,t} = \; c + \alpha_i + \tau_t + \sum_{p=1}^{8} \beta_p * SubIndex_{p,i,t} + \gamma * Deaths_{i,t-1} + \varepsilon_{i,t} \quad (3)$$

Secondly, we introduce the dummies that the sub-indices are built from directly in the equation (Equation 4). Unlike previously, Equation 4 gives the same weight to each intervention, regardless

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of its level of intensity. This allows us to evaluate the role of each NPI's intensity and see if the introduction of a level 1 NPI is associated with the same elasticity as a level 2 or level 3 NPI.

$$Mobility_{i,t} = c + \alpha_i + \tau_t + \sum_{p=1}^{23} \beta_p * NPIdummy_{p,i,t} + \gamma * Deaths_{i,t-1} + \varepsilon_{i,t} \quad (4)$$

Thus, Equation 3 can identify the kind of NPI that tends to reduce mobility while Equation 4 identifies which levels of NPI are associated with greater reductions in mobility.

b. Results

Equations 3 and 4 are estimated over the first and second waves. Figure 14 shows the results for the first wave. These results suggest the closure of workplaces and stay-at-home requirements have had the most effect on the decrease in mobility during the first wave. Stay-at-home requirements, however, are only significant at the 90th percentile level. Similar results appear for restrictions on public transports, school closures, restrictions on gatherings (at the 90th percentile level), and, to a lesser extent, restrictions on internal movement. Border controls and cancellations of public events do not appear to have affected mobility.

These results should be interpreted with caution given their rapid implementation in sequence. Indeed, Figure 15 shows that, during the first wave, the different types of NPIs were set up quickly one after the other in our sample. On average, a few days separate their implementation over a total window of 17 days[10]. Thus, distinguishing for example the effect of restrictions on internal movements from the effect of containment is difficult as 24 hours separate their implementation on average. Besides, these coefficients can be interpreted as marginal effects associated with the addition of each measure rather than as absolute value effects. This interpretation is also underlined by the IMF (2020) and would mean that the coefficients displayed here under-estimate the effects of each restriction individually. In any case, it seems difficult to draw definitive conclusions about the relative impact of different types of NPIs on mobility.

[10] This tight sequencing for these 29 countries is surprising as countries faced different COVID shocks during the first wave. Yet, many countries adopted preventive NPIs then. In addition, some researchers have highlighted a phenomenon of mimicry between countries, which would explain the diffusion of homogeneous NPI when the situations were heterogeneous (Sebhatu et al., 2020).

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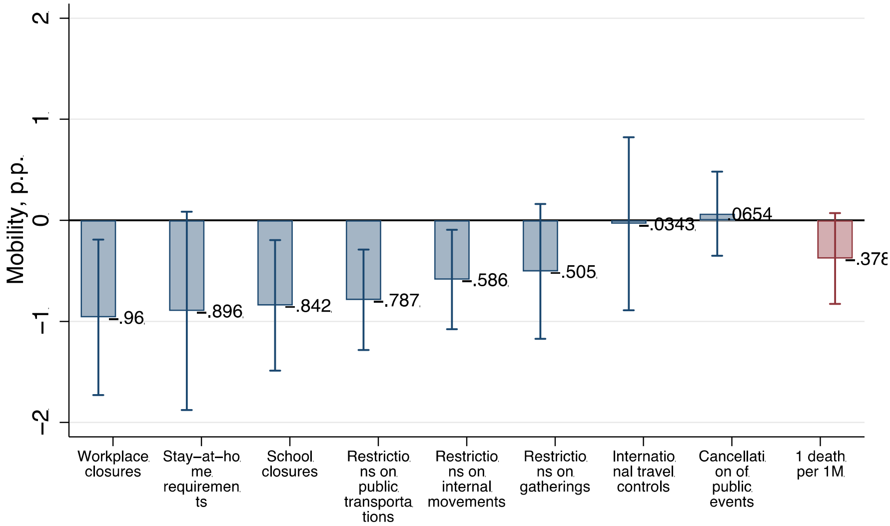
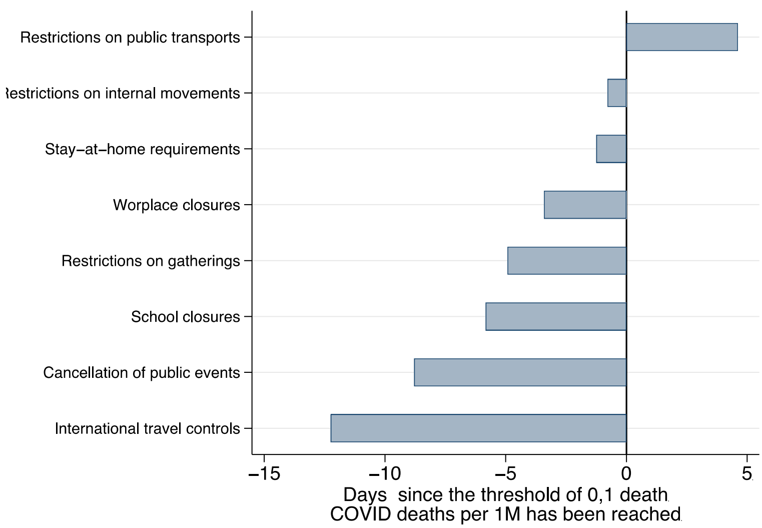
<u>Figure 14:</u> Effects of different types of NPIs and COVID deaths on mobility during the first wave (increase of 10 p.p. for each sub-index)



Note: 95% confidence interval. Detailed regression results available in the appendix, Table A7.

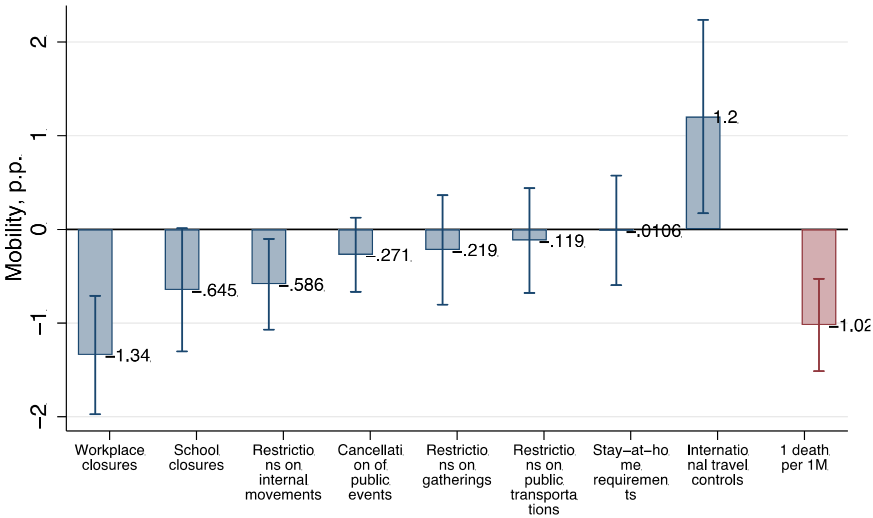
<u>Figure 15</u>: Average sequencing of the implementation of NPIs during the first wave, by type of NPI, in advanced OECD countries



Note: The threshold of 0,1 daily deaths to 1 M was arbitrarily chosen and represents a threshold from which the reality of the COVID crisis is evident in the country. This sequencing is only shown for the first wave as the chronology of the second wave has been more heterogeneous. Besides, several NPIs put in place during the first wave have never been lifted afterwards (for example restrictions on gatherings or event cancellations).

During the second wave, stay-at-home orders no longer have a significant effect on mobility and workplace closures remain the most effective measure (Figure 16). This is consistent with the generalisation of teleworking during this period and the lower prevalence of stringent lockdown. They are followed by school closures (significant at 10%) and restrictions on internal movements. Cancellations of public events, restrictions on gatherings, and restrictions on public transport do not have a significant effect, which is likely due to less variation in these types of NPIs in the second wave. Most of these NPIs were implemented during the first wave and never lifted. International travel controls have a positive and significant effect. This last result could come from a correlation between the resumption of economic activities in certain countries and the implementation of health protocols to travel. Indeed, screenings and quarantines are types of international travel controls. Hence, their implementation might have enabled a resumption of some tourism and business travel activities, and therefore an increase in mobility in some countries. In addition, there has been a temporary increase in air travel during the summer and Christmas holidays that might have been captured in our coefficient (see Figure A3).

<u>Figure 16:</u> Effects of different types of NPIs and COVID deaths on mobility during the second wave (increase of 10 p.p. for each sub-index)



Note: 95% confidence interval. Detailed regression results available in the appendix, Table A7.

These early results seem to show that the most stringent NPIs - the closure of workplaces and stay-at-home requirements in the first wave and the restrictions on internal movement and teleworking requirements in the second wave - had more important effects. To validate this hypothesis, we now study the effect of different NPI levels on mobility. Similarly, to Égert et al. (2020), dummy variables for each level of NPI are included in our estimations (see Equation 4). Results are presented for the first wave (Figure 17) and the second wave (Figure 18).

Figure 17 is particularly revealing and shows that only high-level NPIs have a significant effect on mobility. Thus, during the first wave, stay-at-home requirements of levels 1 and 2 appear to have had little effect on mobility. Conversely, the stay-at-home orders of level 3 had the strongest effects: they are associated with a decrease in mobility over 10 p.p.

Several interpretations to this result can be put forward:

- The first is that the use of time fixed effects may prevent us from capturing the effects of low-level NPIs. We, therefore, re-estimate our results without time fixed effects (see Figures A4 and A5). As a result, some coefficients become significant, such as cancelled public events of level 2 or international travel controls of level 4. The magnitude of our effects also increases for some NPIs, in particular for stay-at-home requirements of level 3. However, these results are close to those that include time fixed effects and several low-level NPIs remain insignificant.
- The second is that there are too few low-level NPIs in our sample. Thus, results close to zero for scores of 1 or 2 could be due to low statistical power. This hypothesis would also explain why certain NPIs which were significant in Figure 14, for example restrictions on internal movements, are no longer once broken down by level. Nevertheless, the large majority of countries implemented stay-at-home requirements of level 1 or 2 during the first wave. So, while lack of statistical power might play a role, it cannot be the only factor.
- A third is that individuals may adjust their mobility more following the adoption of a range of compulsory measures. In fact, a package of government restrictions was often adopted at the same time. For example, in France, a lockdown, the generalisation of teleworking, and the closure of schools were announced concomitantly during the first wave. Thus, certain dummy variables could absorb both the effect associated with their dummy and others that were implemented at the same time.
- Finally, non-linearity may exist and the effect of an individual NPI may only be felt at a high level of restriction. At first glance, the Égert et al. (2020)'s results, who use a larger sample of countries, do not seem to validate this. Their results show that stay-at-home requirements and workplace closures of levels 1 and 2 affect mobility. However, the other types of NPI follow the same pattern as ours. The differences observed in stay-at-home requirements and workplace closures can partly be explained by the use of a different

sample of countries. Égert et al. (2020) include 128 advanced, emerging, and developing countries and different behavioural responses might have occurred in advanced and developing economies[11]. Therefore, the hypothesis of a non-linearity cannot be ruled out.

These last two points are not exclusive. Despite possible identification issues, non-linearity effects may exist and the more stringent NPIs may be the only ones to have a significant effect on mobility. This interpretation would also be consistent with the country results presented in Part II. In particular, it would partly explain Germany's low elasticity during the first COVID wave. If this interpretation was confirmed and level 1 and 2 measures were sufficient to slow the epidemic significantly while having a limited effect on mobility, then a strategy where mobility restrictions are less strict could become a first-best option. This is what Égert et al. (2020) advocate in their analysis.

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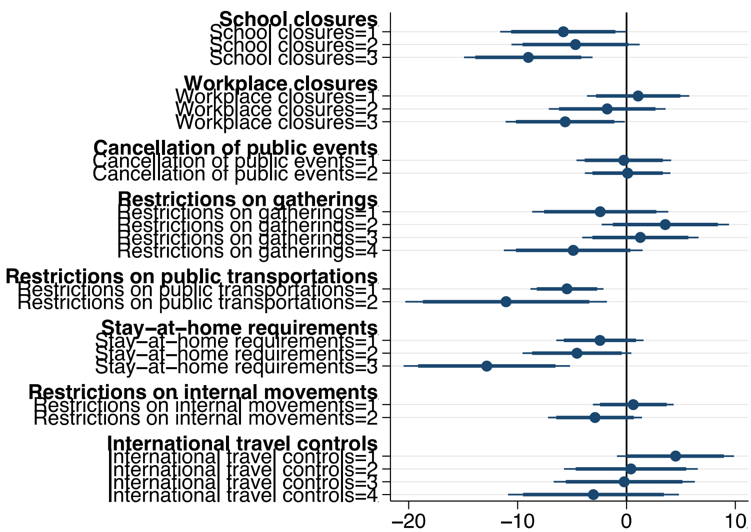
<u>Figure 17:</u> Effects of different levels of NPIs on mobility during the first wave



Note: 90% and 95% confidence intervals. Detailed regression results available in the appendix, Table A8.

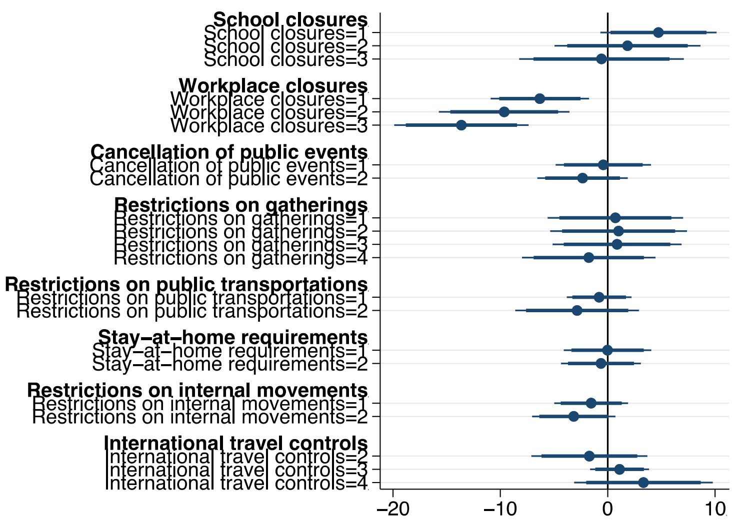
Our analysis by NPI level has so far focused on the first wave. However, the results from the second wave enable us to draw interesting lessons. Figure 18 depicts a situation where only

[11] Their paper also highlights the differences in effect between advanced countries and emerging and developing countries with regard to containments and closures of workplaces. However, their analysis does not make a distinction according to the level of intensity of stay-at-home requirements and workplace closures in advanced countries.

workplace closures affect mobility. This time, the workplace closures of levels 1 and 2 are significant, a sign of greater adoption of teleworking even when this instruction is only recommended. These results echo those presented in Figure 16, where the closure of workplaces and restrictions on internal movements were the only significant measures, the latter being at the limit of significance (and not significant when broken down by intensity level).

The absence of stay-at-home requirements of level 3 shows that NPIs during the second wave were not as stringent as during the first wave. However, the zero effects of level 1 and 2 stay-at-home requirements are puzzling. Indeed, curfews – which are a type of stay-at-home requirements – have been widely used during the second wave, and their effect on mobility has been observed, for example, in Ile-de-France (Valdano et al. 2020). This result appears to be due to the way curfews are measured in the stringency index. In particular, during the second wave, the lockdown implemented in France was assigned a score of 2 in the stay-at-home category. The switch to a curfew at 8 p.m. on December 15 is a relaxation of the measure and was followed by a resumption of mobility. However, the Oxford stringency index also assigns a score of 2 to an 8 pm curfew in the stay-at-home category. Thus, while the measures were eased on December 15 in France, the stringency index does not reflect it. Hence, this choice of measurement prevents us from estimating the effects of lockdowns and curfews adequately during the second wave. This issue of categorisation might become more important as restrictions are implemented at increasingly granular levels.

<u>Figure 18:</u> Effects of different levels of NPIs on mobility during the second wave



Note: 90% and 95% confidence intervals. Detailed regression results available in the appendix, Table A8.

Conclusion

Overall, our results show that NPIs were the main explanatory factor behind the mobility reduction in advanced OECD countries during the first wave. Voluntary distancing then played a more important role during the second wave suggesting (i) a greater awareness of the severity of the health situation and/or (ii) an increase in individual responsibility, while restrictions were less severe during the second wave.

A more detailed analysis of selected countries shows that during the first wave the effect of NPIs on mobility was stronger in France, Spain, and the United Kingdom than in the average of advanced OECD countries. This is probably due to the magnitude of the shock in these countries. Interestingly, Italy stands out as the only country in which mobility decreased both as a consequence of government restrictions and the sanitary situation. The fall in activity in the first half of 2020 was more marked in these four countries.

Reactions across countries were less homogeneous during the second wave. The explanatory weight of NPI in the mobility decline is higher in France, Germany, and Italy, which is explained by the implementation of restrictive measures, and in particular second lockdowns, in these countries. Conversely, countries where the restrictions have been less strict, in part because decisions were adopted at the regional level, see the sanitary situation as the main explanatory factor. It is interesting to note that in France, the daily COVID deaths toll had zero weight on the decline in mobility during the second wave, which could suggest either a lower anxiety-inducing perception of the virus, for example, due to less negative communication, or greater confidence in the respect of individual protective measures, such as mask-wearing and handwashing.

Finally, identifying the most effective type of NPI appears difficult to us. Indeed, the tight sequencing of the implementation of the measures during the first wave leads us to be careful in the interpretation of our results. Besides, the estimates obtained from the second wave, and in particular the null coefficient associated with stay-at-home measures, seem to say more about the categorization of NPIs than their effect. As countries adopt increasingly more granular NPIs the Oxford categorisation might prevent us from identifying precise impact.

More research is needed on the subject: if it were confirmed that looser restrictions give room to greater awareness and empowerment of the population, then another equilibrium than tight mobility restrictions could exist. This would be conditional on the effectiveness of more targeted and less restrictive measures on limiting the circulation of the virus. Yet, if true, an effective strategy to fight the virus could emerge, reconciling health and economic imperatives more effectively than in the first wave.

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Appendix

Table A1: Categories of non-pharmaceutical interventions that compose the Oxford stringency index

Type of NPI	**Stringency score**
School closure	0 No measure 1 Recommended 2 Required for some categories (just high schools or just public schools) 3 Required for all
Workplace closure	0 No measure 1 Recommended (or work from home) 2 Required for some sectors or categories of workers (or work from home) 3 Required for all (or work from home) but essential workplaces (grocery stores, pharmacies)
Cancellation of public events	0 No measure 1 Recommended 2 Required
Restrictions on gatherings	0 No measure 1 Restrictions on gatherings above 1000 people 2 Restrictions on gatherings between 101 and 1000 people 3 Restrictions on gatherings between 11 and 100 people 4 Restrictions on gatherings of 10 people or less

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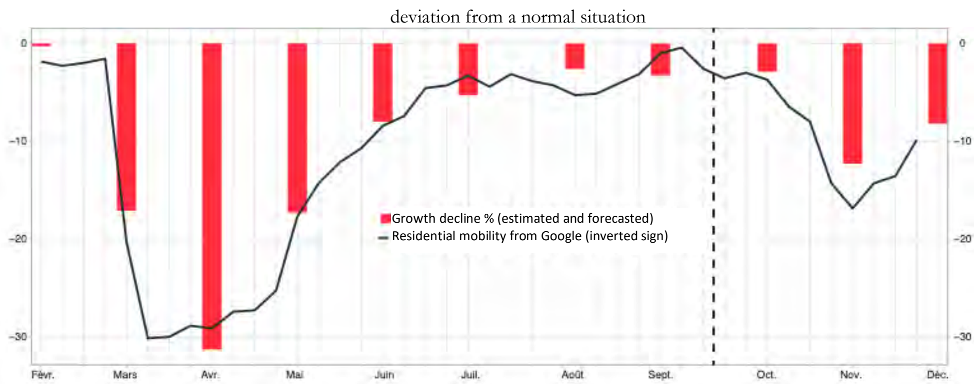
Closure of public transports	0	No measure
	1	Recommended (or significant reduction of the means of transport available)
	2	Required (or prohibits most citizens from using it)
Stay-at-home order	0	No measure
	1	Recommended not to leave the house
	2	Required not to leave the house with the exceptions of daily exercise, grocery shopping, and essential trips
	3	Required not to leave the house with few exceptions (e.g. one person at a time, only once a week)
Restrictions on internal movements	0	No measure
	1	Recommended not to travel between regions
	2	Restrictions on movements between regions
International travel controls	0	No measure
	1	Screening
	2	Quarantines for arrivals from high-risk regions
	3	Ban on arrivals from some regions
	4	Ban on all regions or total border closure

Source: Hale et al. (2020)

<u>Figure A1:</u> Residential mobility and monthly decline in economic activity, estimated and forecasted by the INSEE (extracted from INSEE's "note de conjoncture de décembre 2020")



Reading indication: during the first week of December, people spent 10 % more time at home compared to a normal situation.
Note: Residential mobility data stops on Dec 6th. Weekly values are the averages of the week.
Source: Google, INSEE

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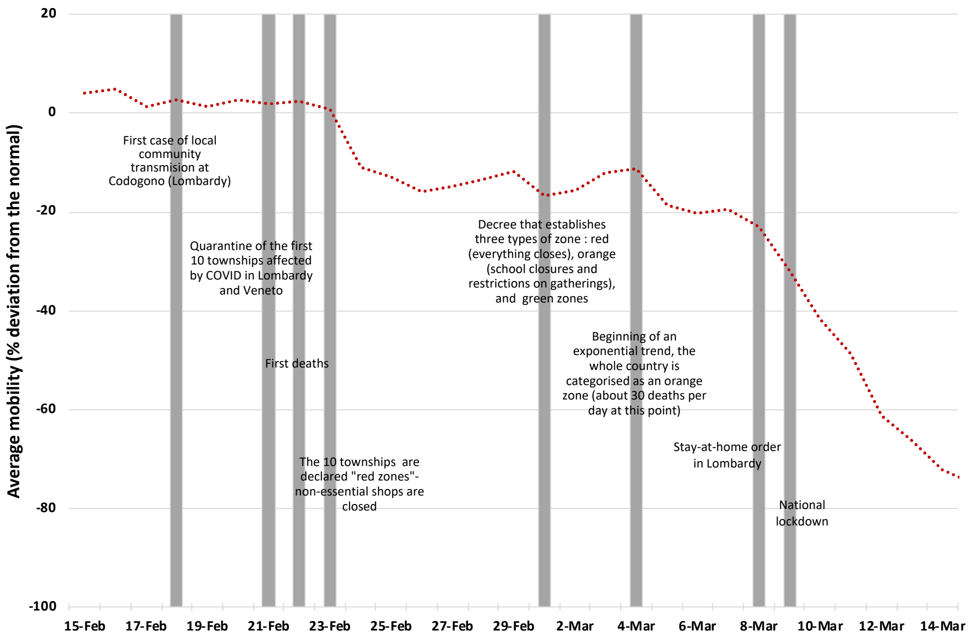
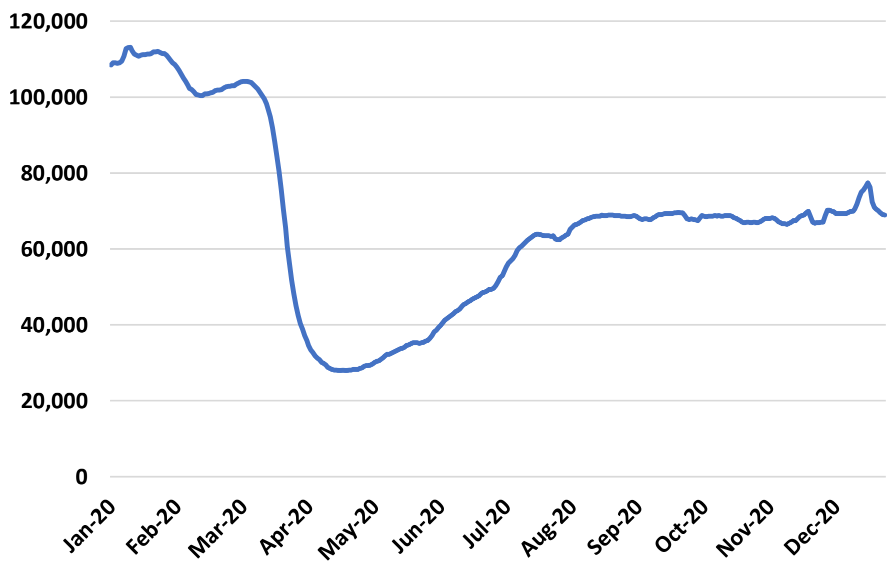
Figure A2: Evolution of mobility in Italy during the first month of the pandemic



Source Google

Figure A3: Daily commercial flights in the world (7-day moving average)



Source: Flightradar24

Tableau A3: Estimation results from equation 1 over the whole period

	(1) Average mobility	(2) Workplace mobility	(3) Retail and recreational mobility	(4) Transit station mobility
Oxford stringency index	-0.396***	-0.281***	-0.522***	-0.384***
	(0.0416)	(0.0386)	(0.0613)	(0.0435)
L.Deaths per million	-0.888***	-0.626***	-1.352***	-0.687***
	(0.182)	(0.155)	(0.245)	(0.205)
Constant	-6.165***	-11.36***	4.261	-11.39***
	(1.950)	(1.780)	(2.974)	(2.133)
Country FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Adj-R2	0.822	0.758	0.818	0.813
N	9496	9496	9499	9499

Standard errors in parentheses, clustered at the country and week level

* $p < .10$, ** $p < .05$, *** $p < .01$

Tableau A3: Estimation results from equation 1 over the first wave period

	(1) Average mobility	(2) Workplace mobility	(3) Retail and recreational mobility	(4) Transit station mobility
Oxford stringency index	-0.468***	-0.402***	-0.574***	-0.428***
	(0.0585)	(0.0660)	(0.0800)	(0.0486)
L.Deaths per million	-0.503*	-0.467*	-0.624*	-0.418*
	(0.262)	(0.267)	(0.311)	(0.241)
Constant	-7.881**	-7.994**	-2.246	-13.40***
	(2.948)	(3.322)	(4.052)	(2.528)
Country FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Adj-R2	0.877	0.810	0.867	0.877
N	3754	3754	3754	3754

Standard errors in parentheses, clustered at the country and week level

* $p < .10$, ** $p < .05$, *** $p < .01$

Tableau A4: Estimation results from equation 1 over the second wave period

	(1) Average mobility	(2) Workplace mobility	(3) Retail and recreational mobility	(4) Transit station mobility
Oxford stringency index	-0.415***	-0.272***	-0.568***	-0.405***
	(0.0412)	(0.0481)	(0.0580)	(0.0411)
L.Deaths per million	-1.125***	-0.689***	-1.543***	-1.142***
	(0.231)	(0.157)	(0.325)	(0.260)
Constant	-1.953	-7.745***	9.873***	-7.980***
	(2.036)	(2.525)	(2.858)	(2.078)
Country FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Adj-R2	0.786	0.732	0.792	0.801
N	3917	3917	3918	3918

Standard errors in parentheses, clustered at the country and week level

* $p < .10$, ** $p < .05$, *** $p < .01$

Tableau A5: Estimation results from equation 2 over the first wave period

	(1) France	(2) Germany	(3) Italy	(4) Spain	(5) United Kingdom	(6) Switzerland
Oxford stringency index	-0.467***	-0.468***	-0.480***	-0.460***	-0.451***	-0.468***
	(0.0588)	(0.0585)	(0.0537)	(0.0607)	(0.0570)	(0.0585)
Country=1 X Oxford stringency index	-0.175***	0.102***	0.135***	-0.172***	-0.241***	-0.00184
	(0.0324)	(0.0201)	(0.0135)	(0.0179)	(0.0478)	(0.0250)
L.Deaths per 1M	-0.403	-0.492*	-0.414	-0.405	-0.495*	-0.498*
	(0.258)	(0.261)	(0.258)	(0.266)	(0.280)	(0.263)
Country=1 X L.Deaths per 1M	-0.616***	0.414	-1.457***	-0.104	0.794**	-0.381**
	(0.193)	(0.459)	(0.286)	(0.230)	(0.335)	(0.169)
Constant	-7.603**	-8.104**	-7.509**	-8.082**	-8.470***	-7.852**
	(3.039)	(2.963)	(2.721)	(3.050)	(2.790)	(2.955)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Adj-R2	0.879	0.877	0.878	0.878	0.878	0.877
N	3754	3754	3754	3754	3754	3754

Standard errors in parentheses, clustered at the country and week level

* $p < .10$, ** $p < .05$, *** $p < .01$

Tableau A6: Estimation results from equation 2 over the second wave period

	(1) France	(2) Germany	(3) Italy	(4) Spain	(5) United Kingdom	(6) Switzerland
Oxford stringency index	-0.410***	-0.409***	-0.418***	-0.415***	-0.420***	-0.423***
	(0.0427)	(0.0418)	(0.0422)	(0.0405)	(0.0424)	(0.0403)
Country=1 X Oxford stringency index	-0.267***	-0.240***	-0.0631	0.464***	0.397***	0.376***
	(0.0863)	(0.0705)	(0.0511)	(0.0835)	(0.0839)	(0.0443)
L.Deaths per 1M	-1.127***	-1.125***	-1.139***	-1.109***	-1.116***	-1.166***
	(0.231)	(0.231)	(0.235)	(0.232)	(0.236)	(0.238)
Country=1 X L.Deaths per 1M	1.058***	0.255	0.581***	0.445	-0.666***	0.182
	(0.361)	(0.149)	(0.184)	(0.414)	(0.208)	(0.173)
Constant	-1.820	-1.827	-1.707	-3.098	-2.543	-1.983
	(2.018)	(2.033)	(2.067)	(2.189)	(2.009)	(1.892)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Adj-R2	0.786	0.787	0.786	0.787	0.786	0.790
N	3917	3917	3917	3917	3917	3917

Standard errors in parentheses, clustered at the country and week level

* $p < .10$, ** $p < .05$, *** $p < .01$

Tableau A7: **Estimation results from equation 3 over the first and second wave periods**

	Mobility 1st wave	Mobility 2nd wave
Stay-at-home requirements	-0.0896*	-0.00106
	(0.0467)	(0.0279)
School closures	-0.0842**	-0.0645*
	(0.0307)	(0.0314)
Workplace closures	-0.0960**	-0.134***
	(0.0366)	(0.0302)
Cancellation of public events	0.00654	-0.0271
	(0.0198)	(0.0189)
Restrictions on gatherings	-0.0505	-0.0219
	(0.0318)	(0.0279)
Restrictions on public transports	-0.0787***	-0.0119
	(0.0237)	(0.0268)
Restrictions on internal movements	-0.0586**	-0.0586**
	(0.0234)	(0.0231)
International travel controls	-0.00343	0.120**
	(0.0407)	(0.0493)
L.Deaths per 1M	-0.378*	-1.020***
	(0.214)	(0.236)
Constant	-12.06***	-15.72***
	(3.794)	(4.287)
Country FE	Yes	Yes
Time FE	Yes	Yes
Adj-R2	0.883	0.792
N	3754	3943

Standard errors in parentheses, clustered at the country and week level

* $p < .10$, ** $p < .05$, *** $p < .01$

<u>Tableau A8:</u> Estimation results from equation 4 over the first and second wave periods

	Mobility 1st wave	Mobility 2nd wave
School closures=1	-5.803**	4.726*
	(2.761)	(2.588)
School closures=2	-4.685	1.842
	(2.803)	(3.249)
School closures=3	-9.019***	-0.581
	(2.808)	(3.666)
Workplace closures=1	1.068	-6.320***
	(2.237)	(2.191)
Workplace closures=2	-1.771	-9.643***
	(2.555)	(2.906)
Workplace closures=3	-5.632**	-13.63***
	(2.607)	(2.993)
Cancellation of public events=1	-0.250	-0.412
	(2.070)	(2.125)
Cancellation of public events=2	0.104	-2.343
	(1.869)	(2.011)
Restrictions on gatherings=1	-2.414	0.713
	(2.974)	(3.013)
Restrictions on gatherings=2	3.560	1.015
	(2.782)	(3.046)
Restrictions on gatherings=3	1.278	0.870
	(2.542)	(2.869)
Restrictions on gatherings=4	-4.894	-1.762
	(3.031)	(2.971)
Restrictions on public transports=1	-5.466***	-0.798
	(1.598)	(1.442)
Restrictions on public transports=2	-11.06**	-2.851
	(4.408)	(2.752)

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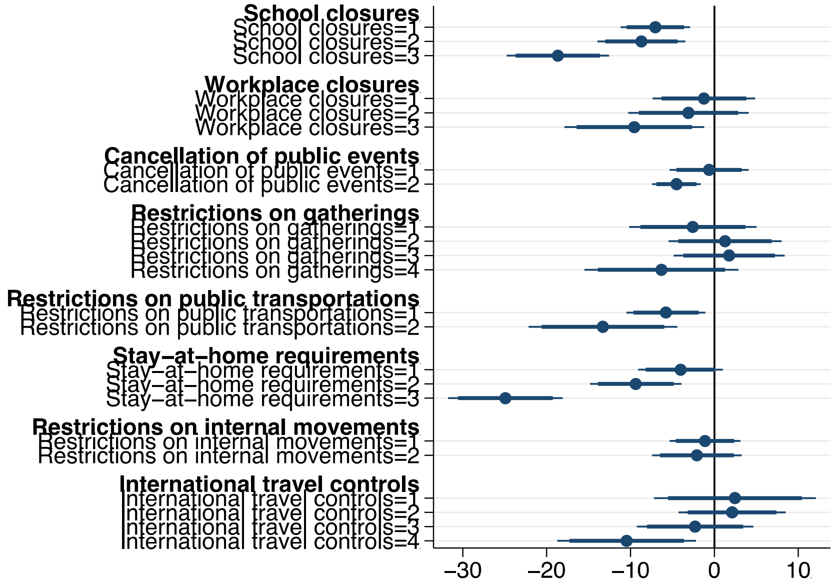
Stay-at-home requirements =1	-2.442	-0.0168
	(1.910)	(1.949)
Stay-at-home requirements =2	-4.550*	-0.626
	(2.375)	(1.778)
Stay-at-home requirements =3	-12.83***	.
	(3.637)	(.)
Restrictions on internal movements =1	0.622	-1.538
	(1.768)	(1.644)
Restrictions on internal movements =2	-2.896	-3.162
	(2.053)	(1.853)
International travel controls =1	4.506*	.
	(2.560)	(.)
International travel controls =2	0.404	-1.709
	(2.926)	(2.579)
International travel controls =3	-0.213	1.101
	(3.087)	(1.311)
International travel controls =4	-3.033	3.327
	(3.733)	(3.085)
L.Deaths per 1M	-0.345	-1.114***
	(0.205)	(0.233)
Constant	-16.70***	-13.41**
	(4.478)	(4.705)
Country FE	Yes	Yes
Time FE	Yes	Yes
Adj-R2	0.890	0.794
N	3753	3908

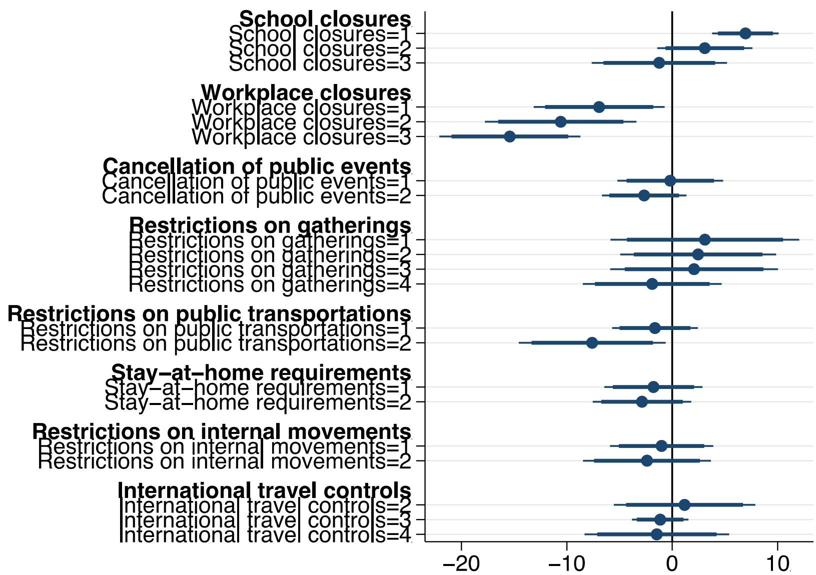
Standard errors in parentheses, clustered at the country and week level
* $p < .10$, ** $p < .05$, *** $p < .01$

Figure A4: Effects of different levels of NPIs on mobility during the first wave, without date fixed effects



Note: 90% and 95% confidence intervals.

Figure A5: Effects of different levels of NPIs on mobility during the second wave, without date fixed effects



Note: 90% and 95% confidence intervals.

Does COVID-19 state aid reach the right firms? COVID-19 state aid, turnover expectations, uncertainty and management practices[1]

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A much debated issue in the COVID-19 state aid to firms is the extent to which these measures keep non-viable firms afloat. What are the characteristics of firms that receive aid and are they viable in the long term? Based on a survey of 1151 firms in the Netherlands, we find that on average, government support goes to better-managed firms and to those with low turnover expectations and high turnover uncertainty. This suggests that COVID-19 state aid tends to go to firms that are most in need of it now and are more likely to be viable in the long term.

1 We would like to thank Jasper Lukkezen, Hans Schenk and Coen Teulings for useful comments and suggestions on prior versions of this paper.
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1 Introduction

Many governments around the world have extended COVID-19 state aid to businesses to minimize the negative effects of COVID-19 public health measures on the economy. These COVID-19 business support measures include loan subsidies, financial support of specific sectors or firm size classes, tax deferrals and the temporary abolishment of bankruptcy regulation. These measures have saved many firms and jobs in the short run. But the historically low bankruptcy rates in many economies have also triggered the question whether these measures have led to a misallocation of resources (e.g. Cros et al., 2021; Gourinchas et al., 2020). One country that has provided substantial COVID-19 support (approximately 10% of GDP; IMF, 2020), but that seems to have a relatively low increase of non-viable (i.e. zombie) firms, is the Netherlands (Lorié & Cubica, 2020). In this paper we perform a microeconomic analysis to find out whether the Dutch government's COVID-19 state aid is well-targeted, in that it reaches the right – i.e. both hard hit and viable - firms.

At the moment, it is still too early to draw robust conclusions on the basis of administrative data: we do not know which firms that have received support will turn out to be viable on the longer run. A reasonable predictor of future viability is organizational capital. There are sound ways to conceptualize and measure the organizational capital of companies, in the form of management practices (Bloom & Van Reenen, 2007; 2010; Bloom et al., 2012), and using those in a survey we can provide insights into the characteristics of firms that have received COVID-19 state aid.

We use regression analysis to show that COVID-19 state aid relatively often ends up at better managed firms and firms that have low turnover expectations and are confronted with great uncertainty about turnover.

2 Government aid to firms: theory and practice

2.1 Welfare economics and business support

In line with welfare economics (Harberger, 1971), business support to firms by governments is legitimized when the economy would be worse off without these interventions. Government intervention that is intended to provide net-benefits to the economy via business support is often confronted with several problems. Two well-known problems of government intervention are ‘deadweight losses’ and ‘substitution effects’, which are likely to play a role in COVID-19 business support as well. In the medium term, business support can lead to deadweight loss: taxpayers'

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money may be spent on firms that would have survived the crisis without state aid (Santarelli & Vivarelli, 2002). In the long run, there is a risk of substitution effects: the failure to select viable firms for government aid means that nonviable firms continue to live at the expense of fundamentally viable ones. This hinders the reallocation of production factors (Barrero et al., 2020), and leads to a loss of organizational capital. This intangible form of capital, which consists of companies' organizational routines, practices and social systems, acts as an important lubricant for cooperation between employees and with third parties and ensures that a firm is more than the sum of its parts (Brynjolfsson et al., 2002; Black & Lynch, 2005; Bloom & Van Reenen, 2007). This capital disappears when a company ceases to exist. The question now is to what extent the COVID-19 state aid actually reaches firms that need it now (no deadweight loss), and also contributes to the productivity of the economy in the longer term (no substitution effect).

2.2 COVID-19 business support in the Netherlands

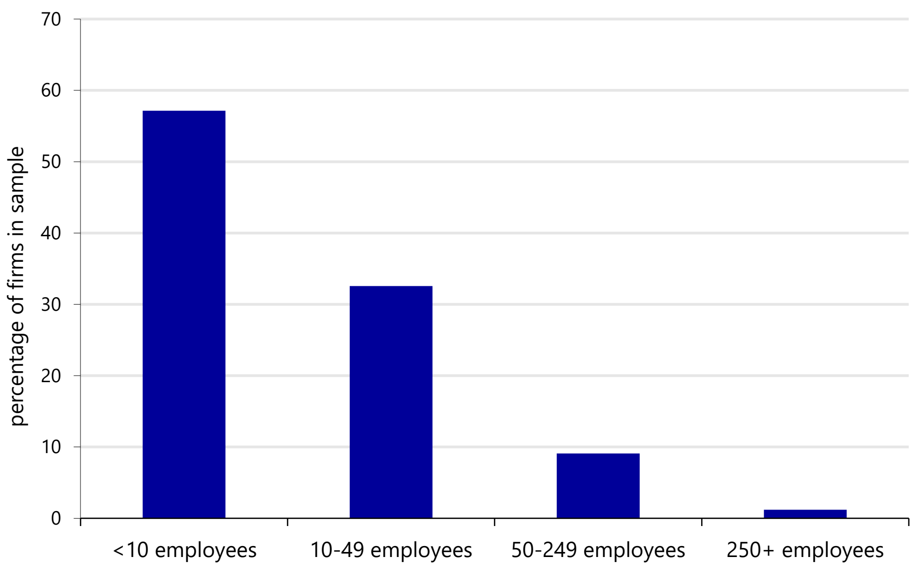
In response to the COVID-19 crisis, the Netherlands, like many countries, has set up generous support schemes for firms. This support is provided to keep up supply capacity (including organizational capital), retain jobs and indirectly to prevent a collapse in aggregate demand (see Baldwin & Di Mauro, 2020; Blanchard et al., 2020). Several of these schemes are specifically aimed at incentivizing firms to retain labor. This includes the NOW scheme which subsidizes up to 90% of labor costs for firms with a turnover reduction of at least 20%. In addition, during the beginning of the crisis the government operated the short-time working scheme (WTV), which provides extended unemployment benefits conditional on employees remaining employed by their employers. Due to overwhelming demand, this scheme has been superseded by the NOW. Aside from support related to labor costs, the government has also provided SMEs with tax-free allowances to finance fixed costs such as rent (TOGS and TVL) and has expanded SME credit guarantees, so that small firms can keep access to bank financing more easily (e.g. BMKB). Hard-hit self-employed workers are eligible for the so-called TOZO scheme, which provides direct cost-of-living compensation. In addition to these various subsidies, the Dutch government has also expanded eligibility for company tax deferrals. In all, the different business support measures add up to approximately 10% of GDP (IMF, 2020), but may increase in the future as the second lockdown is extended.

3 The survey

In order to gain insight into the effectiveness of Dutch COVID-19 state aid, we analyzed the characteristics of companies that have received COVID-19 state aid and those that have not received COVID-19 state aid in the past period (before the second lockdown, starting December 15, 2020). Our research concerns the overall business population and not individual cases of (additional) government aid where national strategic interests apply (see Court of Audit 2020). We conducted a survey among 1151 firms (all clients of one large Dutch bank, the Rabobank) between 22 October and 9 November 2020. Compared to the entire population of firms in the sectors surveyed, firms in manufacturing (19%) and hospitality (23%) are relatively over-represented in our sample, with wholesale and retail still dominating (58% of the sample); meanwhile, "micro firms" (fewer than 10 employees) are relatively under-represented.

Of the firms surveyed, 52% said they had recently received some form of COVID-19 state aid from the government. This is similar to economy-wide data collected by Statistics Netherlands (CBS): of all firms with at least two employees, 48% had benefited from at least one of the support measures up to and including September (CBS, 2020). In our dataset, this concerns the NOW scheme (79% of the firms that received aid), the WTV (41%), tax deferral (45%), the BMKB scheme (7%) and other government aid such as the TOZO scheme (9%).

Figure 1: Size distribution of the sample



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In order to assess the deadweight loss or substitution effects of COVID-19 support to firms, we asked the respondents a number of questions. First of all, to test for deadweight loss, we asked firms about their turnover expectations and turnover uncertainty for the next 12 months. These questions were asked before questions on COVID-19 support, in the questions sequence, so the inquiry about having received COVID-19 support or not cannot have influenced the answers to the questions on turnover expectations and turnover uncertainty. Both questions were asked on a scale from 1 to 5. The assumption is that when firms with low turnover expectations and high turnover uncertainty are more likely to have received government aid, the risk of deadweight loss is limited. Figures 2 and 3 show, respectively, the turnover expectations and turnover uncertainty for the sample, both broken down into firms that did and did not receive COVID-19 state aid. It is clear that firms that have received support usually have large negative turnover expectations and experience high levels of uncertainty.

Even though COVID-19 support seems to reach companies that need it relatively more often, still 12% of the companies that received support have high-very high turnover expectations. The share of supported firms with low-very low uncertainty is very small: only 3%.

In order to find out whether the COVID-19 support reaches firms that are viable in the longer term, and thus limits substitution effects, we asked companies about the quality of their management practices. Companies with better management practices generally achieve better business performance (Bloom & Van Reenen, 2007; Dieteren et al., 2019).

Our survey included a module on management practices. These questions were copied with minor adjustments from the Management and Organizational Practices Survey (MOPS) and the Annual Survey of Entrepreneurs (ASE) (see Bloom et al., 2020). In total, we used 7 questions, listed in Appendix A1. The questions cover personnel practices, the use of key performance indicators, the use of targets, and the handling of issues that arise for the business.

Each answer received a score between 0 and 1. The response which is associated with the most structured management practice is equal to one, and the one associated with the least structured practices is equal to zero. The composite management score used throughout this paper is then the simple average of those scores.

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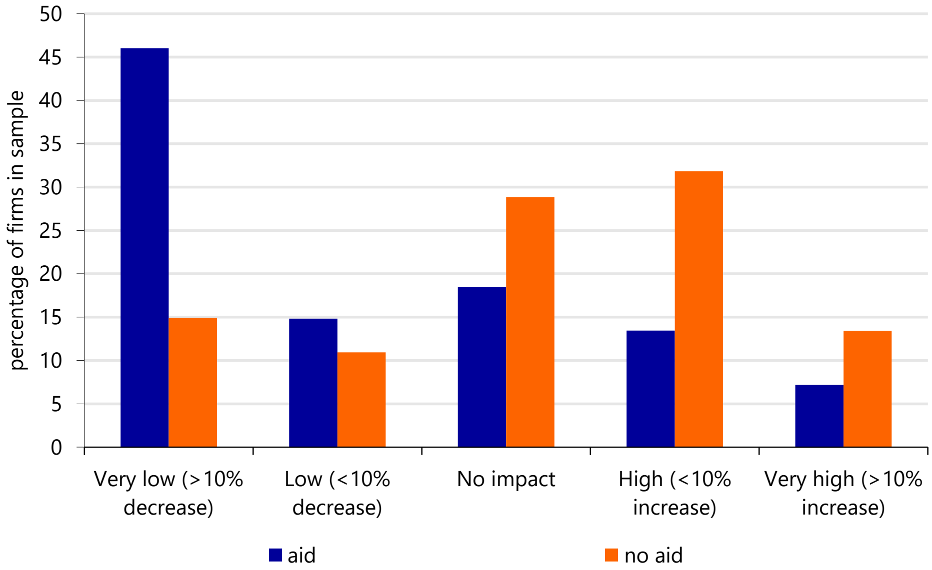
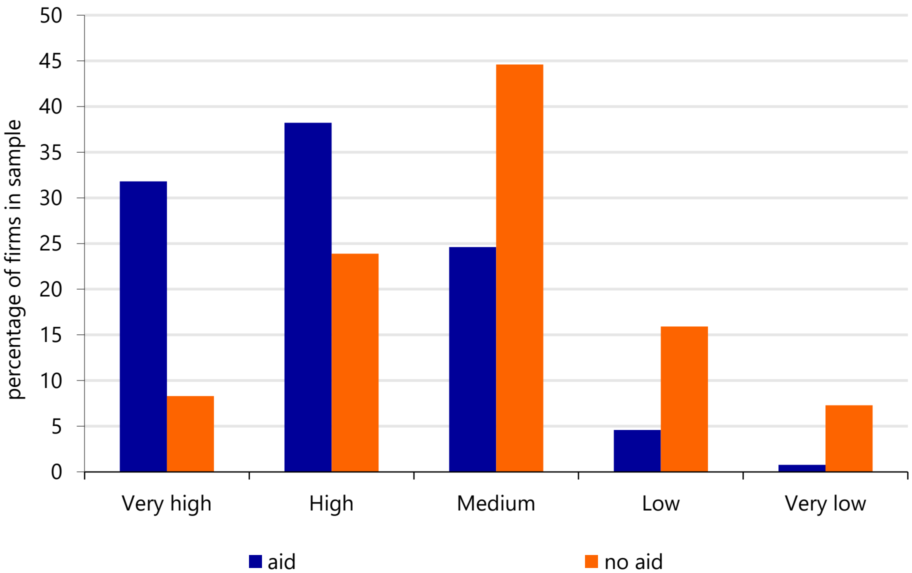
Figure 2: Comparison of turnover expectations between firms that have (blue) and have not (orange) received state aid



Note: The Mann-Whitney U-test shows that firms which have not received Covid-19 government aid have significantly higher revenue expectations than firms that have received aid (z = 12,46).

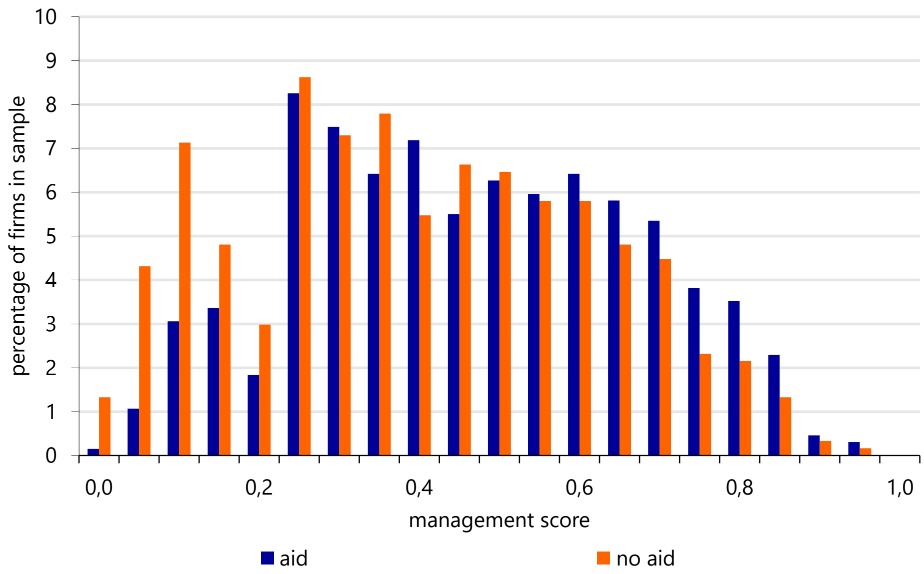
Figure 3: Comparison of turnover uncertainty between firms that have (blue) and have not (orange) received state aid



Note: The Mann-Whitney U-test shows that firms which have not received Covid-19 government aid experience significantly lower turnover uncertainty than firms that have received aid (z = -14,52)

Figure 4 shows the distribution of management scores among the firms in our sample, broken down into companies that did and did not receive COVID-19 state aid. On average, the management score is 0.4 on a scale from 0 to 1. This corresponds with the average from a previous study into the quality of management practices in the Netherlands using a survey with similar questions (Dieteren et al., 2019). Firms that have received government aid appear to have better management practices than firm that have not received government aid.

Figure 4: Overlapping histograms of the quality of management practices of firms that did (blue) and did not (orange) receive government aid



Note: The unpaired t-test shows that firms that did not receive government aid have lower quality of management practices than firms that did receive aid (t = -3,67).

4 Results

Using logistic regression analyses, we examine the relationship between whether or not companies have received COVID-19 state aid and the variables indicating possible deadweight loss (turnover expectations and uncertainty) and substitution effects (management practices) (Table 1). In model 1 we see that government aid is more likely to reach larger firms and firms in the wholesale and retail sector.[1] In model 2, we add turnover expectations and uncertainty to the specification. We do this to check whether the aid ends up with firms that most need it in the short term. Both effects are

[1] We have three sectors in our sample: manufacturing, wholesale and retail, and hospitality. The wholesale and retail sector is the reference category in our model.

significant and have the expected sign: companies with low turnover expectations and high uncertainty are more likely to receive COVID-19 state aid. This suggests that deadweight loss is likely to be limited. Also note that the sector in which a firm operates no longer has a significant impact on the probability of receiving COVID-19 state aid; apart from the fact that some sectors are hit harder than others in general in terms of turnover and uncertainty, there is no additional sector effect left once we take into account the turnover expectations and uncertainty.

Finally, in models 3 and 4 we add management quality. The quality of management practices has a positive and significant effect on the probability that a firm received COVID-19 state aid, on top of the effects of turnover expectations and uncertainty. This indicates that the COVID-19 state aid also ensures the retention of organizational capital, as it on average reaches firms with high quality of management practices. As a result, the substitution effects are also limited. The significant effect of management comes at the expense of the significance of the effect of firm size. Management quality and firm size are strongly related (see Bloom and Van Reenen, 2007; Dieteren et al., 2019), but the latter does not eliminate the effect of management quality.

One concern with measuring the quality of management practices is that not all practices might apply to all kind of firms. In particular, HR management practices might not be relevant for micro firms (< 10 employees). Bloom et al. (2020) therefore suggest to leave out these practices when assessing micro firms' quality of management practices. While target and performance management (setting clear and reachable targets and monitoring and anticipating on their progress) are likely to be relevant for all kind of firms, HR practices make less sense within firms that employ few people. Model 4 presents the results of the same analysis performed in model 3 but now excludes HR practices in our measure of management quality. The results from model 4 are very much in line with the results from model 3: on top of the effects of turnover expectations and uncertainty, the quality of management practices has a positive and significant effect on the probability that a firm received COVID-19 state aid.

Table 1. Logistic regression analysis with a binary COVID-19 state aid indicator as dependent variable

	(1)	(2)	(3)	(4)
Quality of management practices			1.220***	
			(0.455)	
Quality of management practices (excl. HR)				1.103**
				(0.440)
Neutral turnover expectations		-1.169***	-1.197***	-1.198***
		(0.186)	(0.197)	(0.198)
Positive turnover expectations		-1.045***	-1.334***	-1.331***
		(0.262)	(0.294)	(0.295)
Medium uncertainty		0.962***	0.916***	0.929***
		(0.235)	(0.268)	(0.268)
High uncertainty		1.893***	1.927***	1.943***
		(0.235)	(0.267)	(0.266)
Log number of employees	0.196***	0.207***	0.121*	0.147**
	(0.051)	(0.055)	(0.070)	(0.067)
Hospitality sector dummy	-0.131	-0.057	-0.133	-0.127
	(0.159)	(0.186)	(0.203)	(0.203)
Manufacturing sector dummy	-0.299**	-0.156	-0.289	-0.287
	(0.147)	(0.166)	(0.182)	(0.182)
Firm controls	Y	Y	Y	Y
Respondent controls	Y	Y	Y	Y
Constant	0.592	0.036	-0.213	-0.213
	(0.603)	(0.780)	(0.830)	(0.828)
Number of observations	1,084	1,035	884	884
Pseudo R-squared	0.030	0.178	0.198	0.197

Note: Models contain the results of logistic regression analyses with Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1). The sector reference category is retail. The five answer categories for turnover expectations and turnover uncertainty have been reduced to three dummy variables each. For turnover expectations the middle three categories have been bundled; for turnover uncertainty both outer two categories. In all models we account for other firm controls (ownership and firm age) and respondent controls (age, gender, responsibility within the firm, and time taken to complete the survey)

5 Conclusion

Our empirical analysis of the effectiveness of the COVID-19 state aid shows that this support mainly reaches firms that need it in the short term because of poor turnover prospects and great uncertainty, and which, on average, are likely to be viable in the longer term as measured by the quality of their management practices. The degree of deadweight loss and substitution effects in government aid therefore seems limited in the Netherlands. This suggests that the Dutch COVID-19 state aid is effective and efficient in its direction. Our study does not analyse whether the size of the state aid is justified.

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The question is, however, whether the lack of deadweight loss and substitution effects and the preservation of organizational capital so far are the result of targeted policies or are merely a coincidence. Should the latter be the case, the current design of COVID-19 state aid does not in any way guarantee that subsequent support measures will ensure the preservation of organizational capital. This would require an explicit assessment of whether firms eligible for COVID-19 state aid have high quality of management practices and thereby good organizational health. This could prevent the substitution effects mentioned before. Organizational capital seems to be an easier characteristic of the viability of companies to measure than, for example, the extent to which they manage to achieve the most profitable product-market combinations in the next three years. To prevent deadweight loss related to COVID-19 state aid, governments could set up a mechanism through which firms can quickly repay aid when it turns out they do not need it.

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Appendix A1 – Survey questionnaire

In the survey firms were (a.o.) asked to respond to a module on management practices. The questions were copied with minor adjustments from the Management and Organizational Practices Survey (MOPS) and the Annual Survey of Entrepreneurs (ASE).

1. How many key performance indicators (KPIs) are monitored at your business?
2. How frequently are KPIs typically reviewed at your business?
3. What did you do when a service or production problem arises in your business?
4. What describes the time frame of your service/production targets?
5. How easy or difficult is it to achieve service, or production targets?
6. What are the primary ways employees are promoted in your business?
7. When is an under-performing employee reassigned or dismissed?

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Economic inequality and Covid-19 death rates in the first wave: A cross-country analysis[1]

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The cross-country relationship between Covid-19 crude mortality rates and previously measured income inequality and poverty in the pandemic's first wave is studied, controlling for other underlying factors, in a sample of 141 countries. An older population, fewer hospital beds, lack of universal BCG (tuberculosis) vaccination, and greater urbanization are associated with higher mortality. The death rate has a consistent strong positive relationship with the Gini coefficient for income. Poverty as measured by the $1.90 per day standard has a small negative association with death rates. The elasticity of Covid-19 deaths with respect to the Gini coefficient, evaluated at sample means, is 0.9. Assuming the observed empirical relationships unchanged, if the Gini coefficient in all countries where it is above the OECD median was instead at that median, 67,900 fewer deaths would have been expected after 150 days of the pandemic - a reduction of 11%. Shrinking higher Gini's down to the G7 median reduces predicted deaths by 89,900, or 14%.

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1 Comments on earlier versions or other help were provided by Charles Beach, Jessica Davies, Herbert Emery, Samantha Goertz, Michael Hoy, Dean Jolliffe, Rodrigo Lluberas, Anthony Shorrocks and Wayne Simpson. Responsibility for any errors or omissions is my own.

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I. Introduction

Disadvantaged minorities and some low-income groups have been hit hard by Covid-19 infection and deaths, suggesting that its severity within countries may have been affected by their degree of economic inequality. Such an impact would be in line with the considerable body of evidence on the impact of inequality on health. This paper asks to what extent differences across countries in Covid-19 crude mortality rates were related to their pre-existing differences in income inequality and poverty in the first global wave of the pandemic, which ended in August 2020. This is done controlling for other important underlying factors.

While international data are available on cases as well as deaths, the focus is on the latter here because they are likely more accurate. The variable studied is the crude mortality rate, that is the cumulative total of officially reported Covid-19 deaths divided by population as of a particular date. This rate will be referred to simply as the *death rate* or the *mortality rate.* In order to control for the length of time the pandemic had been present, the death rates used are those observed 150 days after total confirmed cases in a country had reached 10.

The empirical work reported here controls for pre-existing factors other than income inequality and poverty that are expected to be associated with Covid-19 death rates: the elderly and urban fractions of the population, BCG (tuberculosis) vaccination, level of democracy, GDP per capita (in PPP terms), and the number of hospital beds per thousand. Covid-19 severity in the first wave was of course also likely affected by a host of proximate factors, including testing, contact tracing, lockdowns, mask wearing, social distancing, and travel. While it would be interesting to study their impact, and others have done so, that is not the purpose of this paper. The goal here is to look at the pre-existing underlying factors that may have worked through those proximate causes.

This paper confines attention to the first global wave of Covid-19 for a couple of reasons. One is that by the second wave, which began in September 2020, differences in inequality and poverty across countries had had time to change from their pre-existing patterns, for example because relief payments and other measures countered distributional impacts significantly in most rich countries but less so elsewhere. Another reason is that, at the time that this research was conducted, the second wave was still in progress, and had become more complex than the first wave in key ways, for example with the rise of new variants of the virus and the onset of vaccination programs in many countries at different times and different rates.

While this study finds significant relationships between Covid-19 death rates and income and poverty, it does not establish causation. The results should be taken only as describing the empirical relationship between these variables. Nevertheless, one can explore how death rates would have been altered if one or more of the underlying factors had been different but the empirical relationships between the observed variables remained the same. That is done here in a counterfactual exercise wherein countries with income Gini coefficients above a certain threshold have their Gini's reduced towards it. The results indicate, for example, that if the Gini

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coefficients of all countries were capped at the OECD median, 67,900 fewer deaths would have been predicted after 150 days of the pandemic, while capping country Gini coefficients at the G7 median reduces expected deaths by 89,900. These numbers are 11% and 14% of actual deaths respectively.

As pointed out in the literature review below, some economists have questioned the apparent relationship between income inequality and health outcomes, arguing that it is mostly due to the effects of poverty. Here it is found that income inequality and poverty have distinct relationships with the Covid-19 death rate in cross-country analysis. Moreover, the effects are not in the same direction: income inequality is associated with a higher death rate while poverty is associated with a lower rate.

There has been some previous investigation of the cross-country relationships between poverty and Covid-19 mortality, and also the effect of mean income and other underlying factors, as set out in the next section. However, only one of these studies (International Monetary Fund, 2020) was global in scope and it did not look at the impact of poverty. Also, these studies produced conflicting results on the impact of poverty and did not looked at the effect of income inequality. This paper breaks new ground with an examination of the effects of both poverty and income inequality on Covid-19 mortality on a consistent basis using a global sample of countries. Such a study is urgent not only in light of the seriousness of the Covid-19 pandemic and the possibility of future similar pandemics occurring, but also in view of the strong upward trend in income inequality within many countries around the world that has been seen in recent decades (Davies and Shorrocks, 2021).

The paper proceeds as follows. The next section provides a brief and selective review of relevant literature. Section III then discusses modeling. Section IV describes the data. Regression results and a counterfactual exercise are provided in section V. Section VI concludes.

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II. Literature

This brief overview of some of the most relevant literature begins by looking at studies on the effect of economic inequality, including poverty, on pandemics and on health in general. Then existing evidence concerning the relationship between Covid-19 severity and inequality is examined.

There has long been interest in the relationship between inequality and pandemics (Slack, 1985; Campbell, 2016; Scheidel, 2017; Snowden, 2019). That interest has tended to focus on the effect of a pandemic on inequality, which remains true today (Furceri et al., 2020; Alfani, forthcoming). However, the impact of inequality *on pandemics* has also had some study. In a sociological analysis, Farmer (1996, 2001) argued that social inequalities played a key role in fostering modern epidemics of Ebola, TB and HIV. Anbarci et al. (2012) studied cholera outbreaks in 55 poor countries over 1980-2002, finding that both cases and deaths were negatively related to the availability of clean water, which in turn was reduced by inequality. And Cummins et al. (2016) found that in many outbreaks of plague in London over the period 1560 – 1665, elevated mortality began in poor suburbs rather than in the docks as previously thought, implying an important impact of poverty.

There is a well-developed literature on the impact of inequality on health more generally. The Whitehall studies in the United Kingdom that began in 1967 found that civil servants of higher rank had less heart disease and other chronic conditions, controlling for smoking, physical activity, obesity and other risk factors, despite their similarity of working conditions (Pickett and Wilkinson, 2009, 2015). Status in itself appeared to have a positive impact on health, in part because the low-status individuals were subject to more job stress. These observations contributed to interest in the relative income hypothesis, which posits that health depends on income relative to others in society in addition to or possibly rather than on absolute income. A string of public health studies confirmed the relative income hypothesis. Results were reviewed and summarized in Wagstaff and van Doorslaer (2000), Karlsson et al. (2010) and Pickett and Wilkinson (2015).

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Some economists have concluded that there is not yet convincing evidence that income inequality *per se* generally has a negative effect on health although poverty and other factors that are correlated with income inequality, such as unequal healthcare and government services and racial injustice, do harm health (Deaton, 2003, 2013; Case and Deaton, 2017). These conclusions do not, of course, imply that one should not investigate the relationship between income inequality and Covid-19 severity. It could be that in this case there is an impact distinguishable from that of poverty. And since we know that income inequality is correlated with a range of inequities that have been proven to be related to health, it can at the least serve as a useful proxy for data on those inequities, which are not as readily available.

Covid-19 health impacts among disadvantaged minority groups have received attention in several countries. In the United States black, Hispanic and indigenous people have suffered more than whites (APM Research Lab, 2020; Stafford, Hoyer and Morrison, 2020; Foundation for AIDS Research, 2020). Gross et al. (2020) examined the health-related data for 28 states that reported race and ethnicity-stratified Covid-19 mortality. Controlling for differences in age structure, they found that the risk of death for blacks was 3.6 times that of whites, while the corresponding ratio for Hispanics was 1.9. Similar death rate differentials have been found in the UK among black, Asian, and Middle Eastern, or BAME, groups (Office for National Statistics, 2020; Pubic Health England, 2020), and have been noted widely for minority groups in other countries, including indigenous people in the Americas and Australia (APM Research Lab, 2020; Engels, 2020; Yashadhana et al., 2020).

The incidence of Covid-19 cases and deaths is higher in U.S. counties with relatively more non-whites, but there is a more complex pattern for poverty. Samrachana et al. (2020) find that both cases and deaths are higher in substantially non-white counties that have greater poverty, but that the opposite is true for substantially white counties. Jung, Manley and Shrestha (2020) find a U-shaped pattern of cases and deaths according to poverty rates in counties with high population density, but a unidirectional positive impact of poverty on cases and deaths in low density counties.

Banik et al. (2020) examined the impact of poverty and other underlying factors on Covid-19 outcomes across countries. They studied 29 countries selected as representative of developed and developing countries, finding that the absolute poverty rate has an insignificant negative effect on the Covid-19 case fatality rate except when an interaction with the BCG tuberculosis vaccination rate is introduced. In the latter case, poverty has a significant positive effect except in countries with a relatively high BCG vaccination rate, where the relationship is negative. They find that such factors as the public health system and population structure are "powerful contributory factors in determining fatality rates". They also note that "…poor citizens' access to the public healthcare system is worse in many countries irrespective of whether they are developed or developing countries."

International Monetary Fund (2020) asserts that poverty has worsened Covid-19 impacts, looking across countries, but does not provide evidence to substantiate that. The study does show that death rates are negatively related to the use of the BCG vaccine in a country and to the number of hospital beds per capita. Interestingly, it omitted GDP per capita from its death rate regressions because it had "the wrong sign", that is a positive effect. Miller et al. (2020) also find that BCG vaccination has had a negative impact on Covid-19 deaths in middle-high and high-income countries (as classified by the World Bank) and that the difference in mortality between countries with and without universal BCG vaccination could not be accounted for by differences in mean income.

The mixed evidence on the impact of poverty on Covid-19 severity in the U.S. and internationally, including indications of a negative effect in some cases, is notable. The present study also finds a negative effect. The reasons for this effect are not clear. It is to be hoped that they will become the subject of careful investigation in future research. A conjecture is that many of the poor may be relatively isolated socially due to lack of employment or the means to engage in much market activity. This would militate against infection in the case of an airborne disease like Covid-19. In cross-country comparisons it may also be that countries with more poor people tend to be less integrated into networks of global commerce and travel, again reducing the spread of the disease.

Although they did not look at the impact of inequality or poverty, Sorci, Faivre and Morand (2020) studied the impact of other underlying demographic, economic and political factors on case fatality rates across 143 countries.[1] They found that the case fatality rate was positively related to the percent of population aged 70+, GDP per capita, and a democracy index, while it was negatively related to hospital beds per capita. These are aspects that are kept in mind in the empirical work reported below.

III. Modeling

In order to die from Covid-19 one must first be infected. The crude mortality rate for any population group in a country is the product of its infection rate and its case fatality rate. These two aspects may be affected in different ways by different factors, which is reflected in the following discussion.

Why would one expect the Covid-19 death rate to depend on the level of income inequality? The effects can be either direct or indirect. An indirect effect could arise if, for example, governments were more sensitive to the wishes of people with high incomes. There are more high-income people in more unequal countries, and they would tend to have more influence on policy, at least in democracies. If support for public health programs, and healthcare generally, falls with income, greater inequality could therefore lead to less expenditure on such programs. Or it could be that public education is underfunded and therefore of lower quality in countries with higher inequality, leading to poor public understanding of science-based recommendations for measures to combat infection - - masking and the like. While such effects may be at work, modeling and measuring them is challenging and beyond the scope of this paper.

A positive direct effect of income inequality on the overall death rate is obtained via Jensen's inequality if the mortality probability is a convex function of income. Consider two people who have the same income and the same mortality probability. Take income from one and give it to the other. Income inequality rises and if the crude chance of dying from Covid-19 is a strictly convex function of income, the average probability of dying for these two individuals goes up. This is true whether the mortality probability is rising or falling with income.

Income inequality could potentially be measured with any one of several standard measures of inequality (Sen, 1997; Cowell 2011). The most popular measure by far is the Gini coefficient. This measure has a well-known intuitive relationship with the Lorenz curve, a fundamental tool in inequality measurement. Estimates of the Gini for a large number of countries are included in the World Development Indicators published annually by the World Bank. Those are the estimates used in this paper.

Conceptually, the comparison of two countries' income distributions and mortality situations can be broken into two components: differences in mean income and in inequality. Whether a

[1] The case fatality rate is the official numbers of Covid-19 deaths divided by the number of confirmed cases.

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higher mean leads to a lower crude death rate depends simply on whether the death rate for individuals is falling or rising with income. That is not the case on the inequality side. As mentioned above, whether higher inequality reduces or increases the overall death rate from Covid-19 depends on whether the probability of being infected and dying from the disease is concave or convex in income. Thus, it is not necessary for the death rate to fall with income in order for higher inequality to cause a higher death rate. This means that the way inequality affects the death rate is fundamentally different from how it is affected by poverty. Higher poverty will only raise the overall death rate if the probability of catching and dying from the disease declines with income; concavity or convexity is not the issue.

Some major factors that are relevant to Covid-19 death rates are demographic. Among those, the fraction of the elderly in a population should be important since the case fatality rate goes up strongly at advanced ages. This paper finds that there is also an effect from the rate of urbanization, perhaps due to the greater congestion in urban areas raising infections as well as air pollution.[2] So individual mortality chances depend not just on income, but on age and rural/urban location at the least. Hence population composition according to these factors should affect the overall death rate for a country.

Age income can each be lumped into two categories, creating binary variables to go along with the urban/rural split. Old vs. young, low vs. higher income and urban vs. rural location divide a population into six groups, ranging from the rural /young/non-poor to the urban/old/poor. Total Covid-19 deaths, D, in a country over a given period of the pandemic can be related to the crude death rates m_{ijk} , and population numbers, N_{ijk} for these six groups by:

$$(1)\quad D = \sum_{i=1}^{2}\sum_{j=1}^{2}\sum_{k=1}^{2} m_{ijk}N_{ijk} \ , \qquad i,j,k = 1,2$$

where $i = 1$ stands for rural, $i = 2$ for urban, $j = 1$ for young and $j = 2$ for old, and $k = 1$ for non-poor and $k = 2$ for poor. We may let

$$(2)\quad m_{ijk} = m_{111} + p_{ijk} \ , \qquad m_{111} \geq 0,\ p_{111} = 0,\ -m_{111} \leq\ p_{ijk} \leq 1 - m_{111}$$

where p_{ijk} is a "premium" on the mortality rate for the urban, old or poor. Note that p_{ijk} could be negative.

A Simple Model

A simple model is obtained if we assume that the death rate premia for being urban, old or in poverty are additive. Letting the additive components be $\pi_u, \pi_o, and\ \pi_v$ respectively, in that case we have:

$$(3)\quad m_{ijk} = m_{111} + p_{ijk} = m_{111} + (i-1)\pi_u + (j-1)\pi_o + (k-1)\pi_v \quad , \ i,j,k = 1,2$$

[2] Using global data Pozzer et al. (2020) find that air pollution makes a significant contribution to Covid-19 mortality.

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and (1) becomes:

(1') $D = m_{111}N + \pi_u N_u + \pi_o N_o + \pi_v N_v$

where N is the size of the total population, and $N_u, N_o,$ and N_v are the number of urban, old and poor people, respectively. Dividing by N we have the death rate equation:

(4) $d = \frac{D}{N} = m_{111} + \pi_u n_u + \pi_o n_o + \pi_v n_v$

where n_u, n_o and n_v are the fractions of the population that are urban, old or poor.

An advantage of this formulation for applied work is that data on d, n_u, n_o and n_v are readily available. Nevertheless, the assumption that the mortality premia for being urban, old or poor are additive may not be correct, so that one should check for interactions between these variables in empirical work.

How do mean income, income inequality and other underlying factors work into the analysis? If such factors only shift the base mortality rate, m_{111} , up or down, they can be accommodated by simply adding other variables to (4) in an estimating equation. These additional variables could be in polynomial form if there are non-linear effects. It is possible that the additional factors could affect the m_{ijk}s non-uniformly, creating interactions between them and n_u, n_o or n_v.

Some potentially important underlying factors are not readily observed or easily compared across a large group of countries. Such factors may include customs and attitudes, political aspects not picked up, say, in a democracy index, climate/weather, travel patterns, and even the incidence of protective genes. While it may not be easy to quantify these aspects adequately, it may be possible to take them into account to an extent implicitly if there is sufficient similarity in these respects within world regions on these counts, motivating the use of regional dummies as in the empirical work reported in this study.

This discussion points to the use of the following estimating equation:

(5) $d = a_o + a_1 Gini + a_2 Pov + a_3 Age + a_4 Urban + a_5 X + \varepsilon$

where $Gini$ and Pov are of course the Gini coefficient and a poverty index, while Age and $Urban$ are respectively the number of elderly and urban residents as a percent of population. X is a vector of other underlying factors, which in this study will include healthcare variables, mean income as captured by GDP per capita, a democracy index and regional dummies. Non-linear and interaction terms can also be introduced, and are investigated in the empirical exercise of section V. No strong assumption is made on the distribution of ε other than it has mean zero and finite variance, and is not necessarily homoscedastic.

IV. Data

Table 1 lists the variables used in the regressions reported in the next section, along with their descriptive statistics. The data are for the most recent available year prior to 2020, as indicated in the Description column.[3]

The variable Deaths is the cumulative total of deaths per million population in the first 150 days of the pandemic in a country, counting from the date by which at least 10 confirmed cases had been recorded.[4] The Deaths observation date for 93 countries is in August, the last month of the first Covid-19 wave.[5] Another 29 countries' death totals were observed in July, and all but three of the remaining countries' deaths were observed in late June or in September.

There is high variation in Deaths across countries. Eight countries, including for example Tanzania, Thailand and Sri Lanka, had fewer than one death per million, while at the other extreme, Belgium, Spain and Peru had more than 600 deaths per million. Although at the extremes for the world as a whole these countries were not such outliers in their own regions or among their peers. Five out of the ten countries with the fewest deaths per million were in Sub-Saharan Africa while six European countries were in the top ten. No OECD countries were in the bottom 20, while eight were in the top ten.[6]

The Gini coefficient has an unweighted mean of 38.5 and a median of 36.7. It varies quite widely, from 24.2 in Slovenia to 63.0 in South Africa. Among the G7 countries, the lowest Gini coefficients are seen in France (31.6) and Germany (31.9), while the highest are found in Italy (35.9) and the U.S. (41.4). Among large emerging market countries, Russia (37.5) and India (37.8) are at the low end while Brazil (53.9) and South Africa (63.0) are at the high end. Many countries in Africa and Latin America have quite high-income inequality; the median Gini coefficient in Sub-Saharan Africa is 44.5 and that in Latin America & the Caribbean is 46.1. High income countries in Northern Europe and the Asia-Pacific region, on the other hand, tend to be at the opposite extreme.

Pov1.9, Pov3.2 and Pov5.5 are the absolute poverty headcount ratios published by the World Bank, calculated using poverty lines of $1.90, $3.20 or $5.50 (USD; 2011 PPP), respectively.

[3] For some countries a variable was not available for the indicated year. In those cases the most recent available year was used.
[4] The date of the first confirmed case is not a reliable indicator of when the pandemic began in a country. There are several countries which reported a single case for many days before numbers began to increase, which may indicate that the initial case was contained and spread of the virus had not begun.
[5] Globally, new Covid-19 cases reached their trough in the third week of August, when the daily average number of new cases was 257,396. After that, numbers began to slowly increase week by week. Deaths reached their trough in the second week of September, with an average of 5,066 deaths per day. See European Centre for Disease Prevention and Control (2021).
[6] The five Sub-Saharan countries in the bottom ten were Botswana, Mozambique, Rwanda, Tanzania and Uganda. The six European countries in the top ten were Belgium, France, Italy, Spain, Sweden and the UK. Together with Chile and the US they make up the eight OECD countries in the top ten.

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Table 1: Data Characteristics

Variable Names	Description	Source	Mean	Median	Standard Deviation	Minimum	Maximum
Deaths	Cumulated Covid-19 deaths per million persons, 150 days after 10th confirmed case	OWID	96.8	27.4	155.7	0.1	848.7
Gini	Gini Coefficient, 2018	WDI	38.5	36.7	8.2	24.2	63.0
Pov1.9, Pov3.2, Pov5.5	Poverty headcount ratio (% of population); with $1.90, $3.20 and $5.50 per day poverty lines (USD, 2011 PPP), 2018.	WDI	13.6 25.1 39.1	2.1 9.7 27.8	20.1 29.3 35.5	0.0 0.0 0.0	77.6 91.0 97.7
SocPov	"Societal poverty" headcount ratio (% of population); poverty line = 50% of median income or consumption with $1.90 PPP per day lower bound, 2018.	WB	27.3	24.0	15.3	3.0	75.8
Age	% of population aged 65 or over, 2019	WDI	9.5	7.0	6.7	1.2	28.0
Urban	Urban population as % of total population 2019	WDI	60.3	61.9	21.1	13.3	98.0
BCG	Dummy: country has a current universal BCG vaccination policy	BCGWA	0.820	1	0.384	0	1
Beds	Hospital beds per 1,000 people, 2015.	WDI	2.8	2.1	2.4	0.1	13.4
GDPpc	GDP Per Capita (USD PPP) 2019	WDI	20,521	13,574	20,717	984	121,293
Democracy	2020 Democracy Index	EIU	5.6	5.9	2.1	1.1	9.8

Notes: 1) BCGWA = BCG World Atlas (2021); EIU = Economist Intelligence Unit (2021); OWID = Our World in Data (2021); WDI = World Bank's World Development Indicators 2020: WB = communication with members of the Development Data Group at the World Bank, as reported in Section IV of the paper.
2) Data are unweighted.

Researchers in the Development Data Group at the World Bank have recently developed a "societal poverty" measure, referred to here as SocPov (Schoch, Jolliffe and Lakner, 2020;

Jolliffe and Prydz, forthcoming). It uses a poverty line equal to 50% of country median income or consumption, but with a lower bound of $1.90 (2011 PPP). While it is a hybrid between relative and absolute poverty measures, since the lower bound is binding for only seven of the countries considered here, for present purposes it is close to a relative poverty measure. Among the poverty measures, Pov1.9 performs best in the regressions reported in the next section.

Per cent of the population aged 65 or more (the variable Age) has a mean of 9.5% and ranges widely, from 1.2% (United Arab Emirates) to 28.0% (Japan). As seen in the next section, this variable is quite strongly related to Covid-19 mortality. Regionally, it is lowest in Sub-Saharan Africa, where its median is just 3.3%, and highest in Europe, where the median is 18.6%.

As found in studies mentioned in section II, BCG tuberculosis vaccination has a negative effect on Covid-19 severity. BCG here is a dummy variable indicating that a country has a current policy of universal BCG vaccination. As indicated by the mean, 82% of countries in the sample have such a policy. The ones that don't are mostly in the rich world, where tuberculosis is no longer a widespread threat. A few countries - - Cyprus, Italy, the Netherlands and the US - - are reported as never having had a universal BCG vaccination policy although they do have vaccination of special groups.

Beds is the number of hospital beds per 1,000 people. As found in the previous studies mentioned in section II, this variable has a negative effect on Covid-19 deaths. It may reflect partly the quality of a country's healthcare system and partly its capacity to handle a surge of patients during an epidemic. The number of hospital beds varies considerably both within and across regions, even when mean income is similar. For example, it is 2.8 per 1,000 in the U.K. but 8.3 in Germany. The range across regions is from a median of 1.0 in Sub-Saharan Africa to 4.8 in Europe.

Alternative indexes are available for the level of democracy by country. Here the index published annually by the Economist Intelligence Unit (associated with *The Economist* magazine) is used. This index is based on assessments of the quality of the electoral process, the degree of pluralism, how well government functions, political participation and culture, and civil liberties. Unlike some alternative indexes, such as Polity IV used by Banik et al., it recognizes differences in the quality of democracy among some rich countries that qualify as democracies but cannot reasonably be regarded as equally democratic.[7]

GDPpc is GDP per capita in USD and 2011 PPP terms. It ranges from $984 in the Central African Republic to $121,293 in Luxembourg. The country mean is $4,037 in Sub-Saharan Africa;

[7] For example, the Polity IV democracy index rates both Norway and the US at 10 on a 10-point scale. In contrast, the EIU index places Norway at 9.81, the highest score awarded, and the US at 7.92, which appears more appropriate given the differences in these countries' electoral practices and systems.

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$6,610 in South Asia, $49,629 in Europe & North America, and between $15,300 and $18,400 in the other world regions.

The final variable is Urban, the fraction of the population living in urban areas. This has a mean of 60.3% and varies widely - - from 13.3 % in Papua New Guinea to 98.0% in Belgium. Other countries with very low urbanization include many in Africa (e.g. Niger, Malawi and Rwanda) and a few in Asia-Pacific (Nepal and Sri Lanka). Countries that are almost as highly urbanized as Belgium include Argentina, Israel and Uruguay.

Table 2 provides information on the regions identified. The regional breakdown is conventional for Latin America & the Caribbean (LAC) , Sub-Saharan Africa (Sub-Sah) , South Asia, and East Asia & Pacific (EAP). MENACA adds Central Asia to the Middle East & North Africa, on the grounds of cultural and socio-economic similarity as well as broadly similar Covid-19 experience. For similar reasons, Europe and North America (including only Canada and the US) are put together in EurNA.

Table 2: Characteristics of Regions

Region	Geographic Description	Number of Countries	Share of Population (%)	Share of Total Deaths (%)	Mean Gini Coeff.	Mean Pov1.90 Headcount Ratio (%)
EAP	East Asia & Pacific	10	29.8	2.1	38.1	1.5
EurNA	Europe & North America	39	14.6	51.3	35.9	0.7
LAC	Latin America & Caribbean	23	8.7	31.5	48.2	4.1
MENACA	Middle East, North Africa & Central Asia	23	7.7	5.8	35.1	5.8
SAsia	South Asia	6	24.7	6.9	36.7	18.2
SubSah	Sub-Saharan Africa	40	14.6	2.4	41.4	45.6
ALL	All regions	141	100.0	100.0	38.6	12.5

Notes: 1) For definitions and sources see Table 1.
2) Means for the Gini Coefficient and Pov1.90 Headcount Ratio are weighted using country population.

One sees wide differences in Covid-19 deaths across regions in Table 2. EurNA and LAC have shares of Covid-19 deaths that are more than three times their share of global population. At the other extreme, SA has a death share equal to about a quarter of its population share, while both EAP and Sub-Sah have death share less than one sixth of their population share. Gini and Pov1.90 also vary widely across the regions, in line with the earlier discussion.

V. Results

Table 3 shows the main regression results. The dependent variable is Deaths, that is Covid-19 deaths per million after 150 days of the pandemic at the country level. The regressions use OLS, weighted by country population. All runs use both the Gin coefficient and the World Bank's absolute measure Pov1.9, based on a living standard of $1.90 (2011 PPP) per day. The regressions can be run instead using $3.20 and $5.50 poverty lines, as well as the societal poverty measure SocPov, which is close to being a relative poverty index, as mentioned in the previous section. Regressions with these alternative poverty measures and the full set of independent variables are reported in Appendix Table A1. Using the alternative measures provides insignificant and slightly less precise estimates of the coefficient on poverty, all of which are negative except for SocPov, which has a positive coefficient. If the Gini coefficient is omitted, the coefficient on poverty is negative and insignificant, whatever poverty measure is used when there is a full set of regressors (Appendix Table A2).

In column 1 of Table 3 a regression of Deaths on Gini and Pov1.9 alone is reported for reference. The variable Gini has a significant positive effect and Pov1.9 a significant negative effect, features that continue through the four following regressions, which introduce regional dummies and then demographic, healthcare, and other variables. [8] The negative association of poverty with Covid-19 deaths across countries may come as a surprise, given it is well established that poverty generally harms health. However, this finding is not inconsistent with findings from the few previous studies that have looked at the effect of poverty on Covid-19 cases and deaths, discussed in Section II. A negative effect of poverty can be reconciled with a positive effect of the Gini, mathematically, if Covid-19 deaths are an *increasing* convex function of income.[9]

The regional dummies have high explanatory power, raising R^2 from 0.164 in the first column to 0.668 in the second, and remaining highly significant when other variables are added. East Asia and the Pacific (EAP) is the omitted category. The largest effects are for Europe & North America (EurNA) and Latin American & the Caribbean (LAC), associated with 134 and 202 additional deaths per million, respectively, in the final regression compared with EAP. Next comes the Middle East, North Africa & Central Asia (MENACA) with 59 extra deaths per million,

[8] As a check on these results the regressions were run using the WIID estimates of the Gini coefficient, as used in Davies and Shorrocks (2021). Results were similar, although the coefficients on Gini and Pov1.9 were somewhat lower. For example, those coefficients were 2.944 and -0.881 in regression 5, compared with 3.566 and -0.781 in Table 3. Also, the p-values were higher for Gini and a little lower for Pov1.9 than seen here.

[9] As pointed out in Section III, inequality will increase average morbidity and mortality, in general, if the latter are convex functions of income, in view of Jensen's inequality. This result does not depend on the sign of the relationship.

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Table 3: Regression Results for First-Wave Covid-19 Deaths per Million

Variables:	(1)	(2)	(3)	(4)	(5)	(6)
Gini	8.091**	4.847***	4.242**	3.482**	3.566**	-9.962**
	(3.786)	(1.698)	(1.702)	(1.574)	(1.529)	(4.384)
Pov1.9	-2.790**	-0.915***	-0.642**	-0.689**	-0.781**	-0.106
	(1.167)	(0.295)	(0.289)	(0.318)	(0.346)	(0.395)
Age			0.265	9.235*	8.901 †	11.190*
			(3.583)	(5.310)	(5.438)	(5.774)
Urban			1.582*	1.275*	1.568**	1.866**
			(0.852)	(0.742)	(0.788)	(0.769)
BCG				-136.008**	-164.817*	-185.660**
				(65.176)	(88.342)	(82.565)
Beds				-20.787*	-18.754*	-18.710*
				(10.557)	(10.846)	(10.662)
GDPpc					-1.410	-1.775
					(1.707)	(1.759)
Democracy					3.266	-87.437***
					(3.910)	(32.581)
Gini x Dem.						2.341***
						(0.844)
EurNA		312.362***	282.584***	138.750***	145.951***	133.899***
		(49.834)	(52.125)	(28.523)	(30.580)	(30.478)
LAC		264.642***	238.889***	233.681***	219.943***	202.273***
		(46.514)	(49.009)	(47.701)	(46.634)	(45.407)
MENACA		77.644***	72.490***	74.496***	73.220***	58.849**
		(16.870)	(27.431)	(24.795)	(24.505)	(25.100)
SAsia		40.277***	77.582***	46.733***	36.950**	41.194**
		(7.665)	(16.044)	(14.860)	(17.372)	(16.004)
SubSah		32.763***	55.650**	61.191***	54.119***	45.104**
		(13.413)	(25.336)	(21.682)	(20.707)	(18.530)
Constant	-190.175	177.198***	253.595***	-86.636	-70.160	435.926***
	(137.876)	(64.930)	(68.191)	(113.458)	(120.566)	(167.639)
N	141	141	141	139	135	135
R Squared	0.164	0.668	0.679	0.762	0.765	0.781

Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$; robust standard errors in brackets; see Table 1 for variable definitions.

and then Sub-Saharan Africa (SubSah) and South Asia (SAsia) at 45 and 41. Given mean deaths per country of 97 unweighted and 87 weighted, these are large effects indeed.

One question that could be asked is whether the regional dummies rob poverty of a positive effect. Table A3 in the Appendix runs the same regressions as shown in Table 3, but without the regional dummies. The coefficient of Pov1.9 is insignificant in all the regressions that include variables beyond the Gini and Pov1.9. Briefly positive, when the demographic variables Age and Urban are first added, it becomes negative as soon as the healthcare variables BCG and Beds are included. These results suggest that using the regional dummies in the main regression results does not obscure a true positive effect of Pov1.9.

The coefficients on both Gini and Pov1.9 fall, in absolute value, when the region dummies are introduced, and then decline a little further in the next four columns, where additional variables are added. The possibility that Gini, Pov1.9 and the other continuous variables had non-linear effects was checked by introducing squared terms, but none proved significant even at the 10% level. A search for interaction effects between Gini and Pov1.9 with all the other variables generated one significant result: a positive interaction between the Gini and the Democracy index that is significant at the 1% level according to a partial F test. This is shown in the final column of Table 3, where one sees that introducing this interaction results in the Democracy level itself becoming significant at the 1% level and also in increased significance for Age and BCG.

At the means, the elasticity of Deaths with respect to Democracy is 0.17 while the elasticity with respect to the Gini is 0.91. The marginal effect of Democracy on Deaths is positive when the Gini is above 37.36, which holds for 68 countries that together have 70.0% of the global population. The marginal effect of the Gini on Deaths is positive when Democracy is above 4.26, which is true for 97 countries that together have 61.7% of global population.

The demographic variables Age (% of population aged 65+) and Urban (% of population living in urban areas) are basic components of the estimating equation (5) derived in Section III. They are each expected to have a positive effect on Deaths. When introduced in the third regression shown in Table 3 they have the expected positive coefficients, but only Urban is significant - - at the 10% level. However, Age becomes significant, also at the 10% level, when the healthcare variables - - the dummy for a universal BCG tuberculosis vaccination policy (BCG) and the number of hospital beds per 1,000 people (Beds) - - are introduced. The latter two variables have relatively large effects. One extra hospital bed per thousand, which would represent an average rise in Beds by about one third across countries, would reduce predicted deaths per million by 19 according to the final regression. Having universal BCG vaccination is associated with a reduction in expected deaths by fully 186 per million.

The last two variables introduced are GDP per capita in 2011 PPP terms (GDPpc) and a democracy index. Neither has a significant effect. In the case of GDPpc this may be surprising, although International Monetary Fund (2020) and Miller et al. (2020) found a similar result, as

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mentioned in section II. The crude correlation of GDPpc and Deaths is positive: the correlation coefficient is 0.414. The inclusion of variables like Age and Urban, which are correlated with GDPpc and have a positive effect on Deaths, appears to reveal that GDPpc does not have a positive direct impact on Deaths. The coefficient on GDPpc is in fact negative, although insignificant.

Counterfactuals

Table 4 reports a counterfactual exercise for the world, regions, and selected countries with large populations in each region. The purpose is to see how much first-wave Covid-19 death rates might have been reduced if countries with above-average Gini coefficients had had less inequality. It is assumed that the empirical relationship between the Gini coefficient and death rates in the data considered here remains unchanged. For this purpose, a regression excluding poverty and the interaction between Gini and Democracy was used (Appendix Table A4). Holding poverty constant while reducing inequality would not have been in the spirit of the exercise. Including the Gini – Democracy interaction leads to implausibly large effects on Deaths of reducing the Gini for countries with either very high or very low values of Democracy. [10]

One approach in this exercise would be to reduce all countries' Gini coefficients by the same amount. However, it is not clear that that is the most relevant exercise. Some countries already have low Gini coefficients. For example, Japan, France and Germany each have a Gini in the range 31.6 to 32.9. At the other extreme we have Brazil, South Africa and 13 smaller countries that all have a Gini above 50. Instead of reducing all Gini coefficients, the Table 4 experiments therefore only reduce them for countries with Gini coefficients above a reasonable threshold. Two alternative benchmarks are used.

The thresholds used in Table 4 are the median Gini coefficient in the OECD (35.6) and that in the G7 (33.8).[11] The table shows the results of shrinking the Gini coefficients of those countries with "excess" inequality relative to the chosen benchmarks, by reducing their Gini alternatively by 50% of the excess and then by 100%. The results are shown in the last four columns of the table.

The counterfactual changes are of course greatest in the "100% shrinkage" case. Total deaths globally would have been smaller by 67,900 using the OECD median Gini target and 89,900 with

[10] For reference, Table A5 in the Appendix reports the counterfactual results using the final regression equation in Table 3, which includes Pov1.9 and the Gini x Democracy interaction. With this alternative procedure the globa reduction in deaths resulting from a reduction in inequality is somewhat smaller.

[11] These medians are weighted by country population. That is, half the OECD or G7 population is in countries that have Gini coefficients below the respective median.

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Table 4: Counterfactual Effects of Changes in Gini Coefficient on First-Wave Covid-19 Deaths

Region/Country	Gini[1]	Deaths per million	Total Deaths	Fall in Total Deaths when "excess" Gini reduced toward median Gini for..			
				OECD by 50%	OECD by 100%	G7 by 50%	G7 by 100%
East Asia & Pacific							
China	38.5	3.2	4,638	4,638	4,638	4,638	4,638
Indonesia	39.0	19.7	5,388	1,610	3,219	2,484	4,967
Japan	32.9	7.7	971	0	0	0	0
Region:	**38.1**	**6.2**	**13,631**	**8,109**	**10,100**	**9,360**	**11,901**
Europe & North America							
United States	41.4	375.0	124,142	3,335	6,670	4,393	8,785
Russia	37.5	96.6	14,104	477	953	943	1,886
United Kingdom	34.8	597.7	40,576	0	0	119	237
Region:	**35.9**	**306.9**	**318,474**	**3,929**	**7,857**	**5,974**	**11,947**
Latin America & Caribbean							
Brazil	53.9	442.7	94,104	6,781	13,562	7,460	14,921
Mexico	45.4	348.1	44,876	2,200	4,399	2,612	5,223
Colombia	50.4	240.7	12,250	1,312	2,625	1,475	2,950
Region:	**48.2**	**317.0**	**201,828**	**13,601**	**26,677**	**15,501**	**30,314**
Middle East, North Africa and Central Asia							
Turkey	41.9	69.3	5,844	923	1,847	1,193	2,380
Iran	40.8	166.4	13,979	758	1,517	1,027	2,053
Egypt	31.5	47.5	4,865	0	0	0	0
Region:	**35.1**	**65.2**	**36,881**	**2,053**	**4,069**	**2,941**	**5,591**
South Asia							
India	37.8	25.3	34,956	5,229	10,458	9,639	19,278
Pakistan	33.5	26.7	5,892	0	0	0	0
Bangladesh	32.4	21.1	3,471	0	0	0	0
Region:	**36.7**	**24.5**	**44,506**	**5,240**	**10,469**	**9,650**	**19,289**
Sub-Saharan Africa							
South Africa	63	161.9	9,604	2,834	5,669	3,024	6,048
Kenya	40.8	8.8	472	472	472	472	472
Nigeria	35.1	4.7	973	0	0	468	936
Region:	**41.4**	**14.5**	**15,557**	**5,745**	**8,750**	**6,873**	**10,807**
World	**38.6**	**87.2**	**640,877**	**38,677**	**67,922**	**50,298**	**89,949**

1.Region and World Gini coefficients are country population weighted means.

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the G7 target, rounding off to the nearest 100. These reductions are 11% and 14%, respectively, of the actual total deaths of 640,877.[12]

The counterfactual reductions in total deaths vary considerably by region. The absolute reductions differ depending not only on the size of the average “Gini excess” in a region but also on its population. Further, the simulated reductions are not allowed to exceed the actual number of Covid-19 deaths in a country, which is a binding constraint in some of the runs for China and Kenya.

A smaller population and low excess inequality lead to the small counterfactual death reductions in the Middle East, North Africa and Central Asia (5,504 at the most), while Latin America and the Caribbean, with similar population but much higher inequality has a much larger reduction (29,813 in the most extreme case). South Asia and East Asia & the Pacific have fairly large reductions (18,960 and 11,816 at the most), not because of high inequality but due to large population.

Country level results are striking. Six of the 18 countries highlighted in the table have a zero reduction in deaths in the OECD target case, because their actual Gini is less than the OECD median. Four - - Bangladesh, Egypt, Japan and Pakistan - - continue to have no reduction in the G7 target case. At the other end, another four countries- - Brazil, India, South Africa and the United States account for 53% of the total reduction of deaths in the “full shrinkage” OECD target case and 54% in the corresponding G7 case.

The United States had the largest number of deaths, accounting for 19% of recorded global Covid-19 deaths here, despite being one of the richest and most advanced countries. Its case is therefore of particular interest. Canada is a natural comparator for the US and, conveniently, has the G7 median Gini of 33.8. The G7 case in Table 4 therefore indicates the result of shrinking a country’s Gini down toward Canada’s level, if its Gini is above that. If done fully, the counterfactual calculation suggests, that shrinkage would have resulted in 8,636 fewer deaths in the US, a drop equal to 7.0 % of actual deaths. Reducing US deaths per million to the Canadian level would be a 37.7% drop. Hence, according to this calculation, the higher Gini coefficient in the US accounts for 19% of the gap between its deaths per million and those of Canada.

VI. Conclusion

It has been found that first-wave Covid-19 crude death rates by country were consistently and positively related to the Gini coefficient for income. Absolute poverty was found to have a significant negative effect in this setting. At the margin a one percentage point increase in a

[12] The reduction in deaths is not directly proportional to the % Gini shrinkage because in some cases the calculation would lower a country’s Covid-19 deaths below zero, if not corrected. A zero lower bound on these deaths is applied, and binds more often under 100% shrinkage.

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country's Gini coefficient yielded 2.0 additional deaths per million people. The elasticity of deaths with respect to the Gini, evaluated at the means was 0.9.

The regressions indicate that two underlying factors that might be expected to reduce Covid-19 deaths had no significant effect: GDP per capita and democracy. The impact of other underlying factors is more as expected. The percent of elderly in the population, and the % living in urban areas, both have a positive impact while the number of hospital beds per thousand has the opposite effect. Having universal BCG vaccination reduces deaths substantially.

Differences in Covid-19 death rates across countries and regions are striking. Deaths in Latin America and the Caribbean, and in Europe and North America, were over 300 per million, while at the opposite extreme, in East Asia and the Pacific, they were only six per million. These regional differences are partly related to the variables included in the regressions, but the size of the coefficients on regional dummies indicates that the differences are also due to unobserved factors. The latter may include socio-economic differences, culture, climate, completeness of recorded deaths, travel patterns and various other factors. But these differences are not related to the duration of the pandemic, as deaths are observed 150 days after the onset the pandemic in each country.

The paper ended with counterfactual calculations that assume the empirical pattern shown in the regressions would be unchanged. On this basis, there would have been an appreciable reduction in Covid-19 deaths in the first wave if countries that have high income inequality had had Gini coefficients at, or closer to, the median Gini's for the OECD or G7, which are moderate. If the Gini coefficient in all countries where it is above the OECD median of 35.6 was instead at that median, 67,900 fewer deaths would have been expected after 150 days of the pandemic. That is a reduction of 11% in total deaths. Shrinking "excess Ginis" to the G7 median of 33.8 would have reduced deaths by 89,900, or 14% of actual deaths, according to these calculations.

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Appendix

Table A1: Regressions for First-Wave Covid-19 Deaths per m., Alternative Poverty Measures

Variables:	Pov1.9	Pov3.3	Pov5.5	SocPov
Gini	-9.962**	-10.068**	-10.117**	-7.980**
	(4.384)	(4.217)	(4.008)	(3.992)
Poverty	-0.106	-0.052	-0.131	0.187
	(0.395)	(0.400)	(0.536)	(0.776)
Age	11.190*	11.185*	10.996*	11.444*
	(5.774)	(5.846)	(5.932)	(5.821)
Urban	1.866**	1.857**	1.814**	2.055***
	(0.769)	(0.785)	(0.771)	(0.771)
BCG	-185.660**	-185.550**	-186.841**	-169.075**
	(82.565)	(82.845)	(84.238)	(78.998)
Beds	-18.710*	-18.729*	-18.697*	-20.739**
	(10.662)	(10.685)	(10.638)	(10.464)
GDPpc	-1.775	-1.776	-1.835	-1.434
	(1.759)	(1.777)	(1.847)	(1.691)
Democracy	-87.437***	-88.005***	-87.955***	-74.285**
	(32.581)	(32.060)	(30.379)	(28.721)
Gini x Dem.	2.341***	2.357***	2.361***	1.947***
	(0.844)	(0.819)	(0.783)	(0.721)
EurNA	133.899***	133.659***	132.936***	138.261***
	(30.478)	(30.344)	(31.115)	(30.370)
LAC	202.273***	201.922***	201.452***	216.846***
	(45.407)	(45.160)	(45.297)	(41.836)
MENACA	58.849**	58.568**	58.478**	58.447**
	(25.100)	(25.214)	(24.689)	(24.142)
SAsia	41.194**	41.351***	43.203**	45.887***
	(16.004)	(15.847)	(17.323)	(14.810)
SubSah	45.104**	43.335**	44.831**	40.734**
	(18.530)	19.439)(	(20.013)	(19.036)
Constant	435.926***	440.585***	452.002***	334.010**
	(167.639)	(162.024)	(171.430)	(133.593)
N	135	135	135	136
R Squared	0.781	0.781	0.781	0.791

Notes: † p < 0.15, * p < 0.1, ** p < 0.05, *** p < 0.01; robust standard errors in brackets; see Table 1 for variable definitions.

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Table A2: Regression Results for First-Wave Covid-19 Deaths per million. without Gini, Alternative Poverty Measures

Variables:	Pov1.9	Pov3.3	Pov5.5	SocPov
Poverty	-0.707	-0.564	-0.462	0.126
	(0.445)	(0.486)	(0.606)	(0.726)
Age	8.326	7.992	7.720	9.203*
	(8.326)	(5.336)	(5.430)	(5.348)
Urban	2.041**	1.892**	1.856**	2.337***
	(0.811)	(0.834)	(0.862)	(0.812)
BCG	-144.974	-145.361	-146.879	-133.093
	(89.751)	(90.408)	(91.525)	(84.774)
Beds	-21.459**	-21.394*	-21.493**	-23.786**
	(10.826)	(10.839)	(10.778)	(10.558)
GDPpc	-1.189	-1.251	-1.333	-0.848
	(1.704)	(1.731)	(1.810)	(1.623)
Democracy	4.047	4.949	4.770	1.020
	(4.118)	(4.674)	(4.919)	(3.152)
EurNA	140.960***	140.137***	137.476***	141.465***
	(30.876)	(31.119)	(32.057)	(30.217)
LAC	236.737***	234.999***	232.591***	249.195***
	(49.541)	(49.575)	(50.356)	(45.325)
MENACA	53.893**	53.774**	52.622**	50.243**
	(21.404)	(21.864)	(21.903)	(20.935)
SAsia	31.149*	37.318**	33.962*	34.006**
	(18.069)	(17.605)	(17.742)	(14.998)
SubSah	60.468**	56.848**	45.502*	36.915
	(26.438)	(27.256)	(23.054)	(24.098)
Constant	28.175	42.925	60.019	-0.498
	(105.038)	(108.556)	(121.837)	(105.593)
N	135	135	135	136
R Squared	0.756	0.756	0.755	0.772

Notes: † p < 0.15, * p < 0.1, ** p < 0.05, *** p < 0.01; robust standard errors in brackets; see Table 1 for variable definitions.

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Table A3: Regression Results for First-Wave Covid-19 Deaths per Million, without Regional Dummies

Variables:	(1)	(2)	(3)	(4)	(5)
Gini	8.091**	5.566*	5.354**	4.817**	-14.174***
	(3.786)	(2.906	(2.313)	(2.047)	(4.974)
Pov1.9	-2.790**	0.348	-0.122	-0.436	0.365
	(1.167)	(1.184)	(0.559)	(0.486)	(0.626)
Age		5.302	10.514**	7.747 †	12.029**
		(5.813)	(4.851)	(5.482)	(5.643)
Urban		3.461***	3.408***	3.926***	3.848***
		(1.055)	(0.875)	(0.997)	(0.959)
BCG			-167.624***	-217.008**	-232.914***
			(57.520)	(87.949)	(87.296)
Beds			-31.970***	-23.677**	-24.106**
			(9.873)	(9.843)	(10.020)
GDPpc				-2.213	-2.668
				(1.933)	(1.941)
Democracy				12.169*	-114.361***
				(6.371)	(38.961)
Gini x Democ.					3.274***
					(1.005)
Constant	-190.175	-373.559***	-173.348***	-153.708	556.595***
	(137.876)	(120.748)	(147.481)	(138.519)	(203.550)
N	141	141	139	135	135
R Squared	0.164	0.375	0.649	0.670	0.704

Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$; robust standard errors in brackets; see Table 1 for variable definitions.

Table A4: First-Wave Covid-19 Deaths per Million Regression without Poverty variable or Gini-Democracy Interaction

Variables:	Coefficients		Variables (continued):	Coefficients
Gini	3.492**		**EurNA**	145.508***
	(1.590)			(29.872)
Age	9.216*		**LAC**	215.381***
	(5.397)			(46.937)
Urban	1.682**		**MENACA**	69.921***
	(0.791)			(24.358)
BCG	-155.547*		**SAsia**	27.881
	(84.351)			(18.820)
Beds	-19.564*		**SubSah**	24.161
	(10.601)			(16.845)
GDPpc	-1.256		**Constant**	-86.743
	(1.664)			(118.717)
Democracy	3.045		**N**	137
	(3.940)		**R Squared**	0.762

Notes: * p < 0.1, ** p < 0.05, *** p < 0.01; robust standard errors in brackets; see Table 1 for variable definitions.

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Table A5: Counterfactual Effects of Changes in Gini Coefficient on First-Wave Covid-19 Deaths, based on regression including Pov1.9 and Gini-Democracy interaction

Region/Country	Gini[1]	Deaths per million	Total Deaths	Fall in Total Deaths when "excess" Gini reduced toward median Gini for..			
				OECD by 50%	OECD by 100%	G7 by 50%	G7 by 100%
East Asia & Pacific							
China	38.5	3.2	4,638	-9,601	-19,203	-15,724	-31,417
Indonesia	39.0	19.7	5,388	2,205	4,411	3,403	5,388
Japan	32.9	7.7	971	0	0	0	0
Region:	**38.1**	**6.2**	**13,631**	**-5,153**	**-12,549**	**-9,993**	**-23,712**
Europe & North America							
United States	41.4	375.0	124,142	8,191	16,381	10,788	21,577
Russia	37.5	96.6	14,104	-302	-604	-598	-1,196
United Kingdom	34.8	597.7	40,576	0	0	340	681
Region:	**35.9**	**306.9**	**318,474**	**8,096**	**16,192**	**11,529**	**23,185**
Latin America & Caribbean							
Brazil	53.9	442.7	94,104	12,109	24,218	13,322	26,644
Colombia	50.4	240.7	12,250	2,449	4,898	2,752	5,505
Mexico	45.4	348.1	44,876	2,675	5,349	3,176	6,351
Region:	**48.2**	**317.0**	**201,828**	**20,533**	**40,714**	**23,282**	**46,198**
Middle East, North Africa and Central Asia							
Turkey	41.9	69.3	5,844	139	277	179	358
Iran	40.8	166.4	13,979	-1,045	-2,090	-1,415	-2,829
Egypt	31.5	47.5	4,865	0	0	0	0
Region:	**35.1**	**65.2**	**36,881**	**-746**	**-1,492**	**-1,217**	**-2,442**
South Asia							
India	37.8	25.3	34,956	8,251	16,502	15,209	30,419
Pakistan	33.5	26.7	5,892	0	0	0	0
Bangladesh	32.4	21.1	3,471	0	0	0	0
Region:	**36.7**	**24.5**	**44,506**	**8,262**	**16,513**	**15,220**	**30,430**
Sub-Saharan Africa							
South Africa	63	161.9	9,604	5,309	9,604	5,664	9,604
Kenya	40.8	8.8	472	258	472	350	472
Nigeria	35.1	4.7	973	0	0	49	98
Region:	**41.4**	**14.5**	**15,557**	**2,255**	**2,420**	**1,586**	**80**
World	**38.6**	**87.2**	**640,877**	**33,247**	**61,798**	**40,470**	**73,738**

1.Region and World Gini coefficients are country population weighted means.

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Firms' investment decisions in response to the COVID-19 pandemic: Causal evidence from Switzerland[1]

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This paper studies how the COVID-19 pandemic affected firms' investment decisions. Combining a survey of Swiss firms with a quasi-experimental research design finds that the pandemic caused firms to reduce their 2020 investment plans by over one-eighth. Firms in regions more exposed to the virus and industries more sensitive to government-imposed restrictions cut their investments more. Both financial constraints and increased uncertainty contributed to downward revisions, which concern investments to extend the production capacity above all. By contrast, the pandemic stimulated investments driven by technological factors or investments of innovative firms.

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1 Introduction

The fast spread of the coronavirus disease 2019 (COVID-19) in early 2020 led governments around the globe to impose drastic measures to contain the pandemic and protect the population. In many countries, public and social life was essentially shut down as part of ordered mass quarantines ("lockdowns"). Businesses were forced to close, curfews imposed, and contact restrictions put into place. The measures resulted in an unprecedented disruption of economic activity, with no clear perspective on when and how quickly the situation would return to normal.

This situation presented many companies with an existential challenge, putting them in a position to make a wide range of important decisions in a rapidly evolving environment characterized by unparalleled uncertainty and determined by questions that only the virus can answer.[1] Such circumstances are likely to have affected firms' investment decisions in particular, which are inherently costly, long-term, and often irreversible. For this reason, the economic crisis associated with the COVID-19 pandemic is an ideal study ground to understand how firms adjust their investment expectations in response to a substantial exogenous shock.

This paper studies how the pandemic affected firms' investment decisions. The analysis aims to understand how the COVID-19 pandemic changed firms' investment expectations, which firms revised their 2020 investment plans in response to the crisis, and what factors drove these revisions. The motivation to understand how firms adjust their investment expectations is twofold. From an academic perspective, heterogeneity in investment decisions, which due to their dynamic nature depend on firms' expectations of future economic conditions, can help uncover the channels through which macroeconomic shocks are transmitted to the real economy. From a policy perspective, knowledge about which interventions affect firms' expectations and how firms respond to them can support the design of more targeted and effective policies.

The empirical investigation uses firm-level data from a Swiss investment survey. Twice a year, this survey collects detailed information on firms' investment activities in the recent past and their investment plans in the near future. It covers firms in the manufacturing, construction, and services sectors and accounts for 58% of total employment (FTE) in Switzerland. Using the survey, I construct a firm-level panel data set composed of 1,200 firms covering the period 2014-2020. These survey data have several desirable properties. First, they include not only realized investments but also planned investments. Second, the investment data are both qualitative and quantitative. Third, many firms' repeated survey over a long period has created a panel with Large-N and Large-T properties. Forth, the survey covers a wide range of firms, from small to large and across all industries in Switzerland, except agriculture. Fifth, apart from data on investments, the survey collects firm-specific information on several factors influencing firms' investment activity, including uncertainty, demand, or technological and financial factors.

The empirical strategy takes advantage of these data characteristics. In autumn 2019 and spring 2020, I observe firms' 2020 investment plans, which allows me to calculate investment revisions as the between-survey change in expected investments for 2020. For identification, I then exploit the fact that the survey in spring 2020 was launched immediately before and conducted throughout the onset of the pandemic. This setup allows me to adopt a difference-in-differences approach to analyze how firms revised their investment plans in response to the COVID-19 pandemic. In particular, I identify the COVID-induced effect on firms' investments by comparing the revision of the 2020 investment plans of companies that completed the survey in spring 2020 before the crisis with those of companies that responded during the crisis. This strategy assumes that the difference in investment revisions between firms responding before and during the crisis is due entirely to the pandemic. I choose 16 March as the cut-off date, when the

[1] Following a statement by Jerome Powell, Chairman of the Federal Reserve System, in his opening remarks at the "Fed Listens" event on 21 May 2020, see Powell (2020).

Swiss federal government decreed a partial lockdown and introduced far-reaching containment measures. These policy decisions have catalyzed the economic dimension of the crisis.

My results show that the pandemic strongly depressed firms' investment plans. In response to the pandemic, firms reduced their gross fixed capital formation by 14 percentage points. This result is driven by investments in equipment and machinery, which firms reduced by as much as a fifth. Conversely, I find no significant effects of the pandemic on investments in construction or research and development. While the pandemic did not influence whether companies invested in replacing worn-out or failing equipment, it lowered the odds of investing to extend production capacity by up to 40%.

However, not all companies revised their investment decisions equally. I find that service providers reduced their investment plans more than manufacturing firms. While small and medium-sized enterprises have cut their investment plans by as much as a quarter, the pandemic did, on average, not cause larger firms to revise their investment decisions. Further, older and exporting firms show a significantly stronger reaction by reducing their planned investments more than younger and non-exporting firms.

The extent to which firms revise their investment plans depends on both the geographic and the sectoral components of the shock generated by the COVID-19 pandemic and the measures taken to contain it. I find that firms in regions more exposed to the virus and industries more sensitive to government-imposed restrictions cut their investments more. For example, in Ticino, the region that was hit first and harder than any other by the pandemic in spring 2020, firms planned to cut their investments in half. Similarly, firms whose production or service provision strongly depend on physical proximity (e.g., restaurants or construction firms) decreased their investment plans more than firms whose operations require less physical proximity (e.g., banks or insurance companies).
By contrast, firms who can efficiently operate from home (e.g., software development) decreased their 2020 investment plans less than firms whose employees cannot work from home (e.g., veterinarians). The few firms that could to increase their investments due to the pandemic stand out as particularly innovative. Human capital accounts for the largest share in their production or service provision, they employ many well-trained workers and have – already before the crisis – largely digitized both internal and external processes by making employees using information and communication technologies for most of their work and using the internet as a channel for both procurement and sales.

Beyond firms' exposure to the virus and their sensitivity to the lockdown, I find evidence that uncertainty and financial constraints are among the main factors influencing firms' investment revisions. The pandemic caused firms uncertain about realizing their irreversible investment plans to decrease their 2020 investments by 20 percentage points more than firms more certain about their planned investments. This result is consistent with real options theory (Bernanke, 1983; Pindyck, 1988; Caballero, 1991), according to which uncertainty increases the option value for wait-and-see behavior, leading firms to postpone their irreversible investments. I consider the magnitude of the effect substantial, reflecting in part the surge in uncertainty in the COVID-19 crisis. Shrouded in a veil of uncertainty, firms at large abandoned their investment plans which they could not have easily reversed.
I find a comparable effect for those investments that firms planned in anticipation of a stimulating financial situation in 2020. Firms that planned to invest based on a positive effect from expected profits reduced their investment plans significantly more than firms that did not make their 2020 investments dependent on their financial expectations. The difference amounts to 21 percentage points. This finding suggests that the pandemic has discouraged firms from investing because of deteriorated financial conditions. This is in contrast to the influence of technological development. The pandemic has caused firms that expected their investments to be stimulated by technical factors to increase their 2020 investments more than firms not anticipating a positive influence from technology. The magnitude of the estimated effect is substantial and amounts to 30 percentage points.

These results contribute to a recent, international, and rapidly growing literature that examines the

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economic consequences of the COVID-19 pandemic, focusing on firm-level behavior using survey data.[2] Only a handful of these contributions to date have examined firms' investment decisions. Balduzzi et al. (2020) field a survey in Italy and document that most firms planned to cut their investments during the crisis. Similarly, Buchheim et al. (2020) study managerial mitigation strategies in the wake of the pandemic and find that firms in bad shape before the crisis were first to cut employment and investment during the crisis. Using data from the same survey and linking it to firm-level uncertainty, Lautenbacher (2020) finds no evidence that firms postponed investment following the COVID-related changes in uncertainty. These papers use either qualitative data on firms' investment responses or firms' investment plans collected during the crisis. My analysis complements these earlier studies by using quantitative investment data from a survey that captured firms' investment plans not just since the crisis but also long before. This panel dimension allows me to quantify changes in firms' investment expectations and convincingly identify the causal effect of the pandemic on various types of investment using difference-in-differences estimations. To the best of my knowledge, my paper is the first to quantify firms' investment revisions in response to the COVID-19 pandemic.

By linking firms' investments to subjective uncertainty as well as demand, financial and technological factors, my results further add to the literature that examines the determinants of firms' investment decisions from a microeconomic perspective. Using survey data on Italian manufacturing firms, Guiso and Parigi (1999) show that uncertainty reduces investments and that the effect of uncertainty is more substantial for firms that cannot quickly reverse their investment decisions. Many empirical contributions have since corroborated this initial evidence for real options theory. Using the same survey as this paper, Binding and Dibiasi (2017) and Dibiasi et al. (2018) document that Swiss firms' investment decisions are consistent with real options. My work contributes to this literature by reinforcing the empirical evidence for real options in firms' investment decisions. Unlike Lautenbacher (2020), it documents this evidence also for the COVID-19 pandemic.

Further, it is part of the literature that addresses the measurement and the analysis of firm-level subjective uncertainty. In the absence of suitable measures of subjective uncertainty, many previous studies have employed proxy measures for firm-level uncertainty.[3] Rather than using another proxy, this paper presents a survey-based measure of uncertainty as perceived by decision-makers within firms about their investment plans, which is hence firm-specific and time-varying. A few surveys have begun to gather data on firms' subjective uncertainty through business surveys in recent years. For the US, Altig et al. (2020) have designed the monthly Survey of Business Uncertainty, which derives uncertainty from firms' freely selected support points and probabilities in five-point distributions over future sales growth, employment, and investment. In Europe, some survey institutes have dedicated a question to firms' uncertainty in their business surveys, for example, the Austrian WIFO (Glocker and Hölzl, 2019) or the German ifo (Lautenbacher, 2020). Meanwhile, the European Commission (EC) discusses introducing a new survey question on uncertainty to harmonize the monthly EC Business and Consumer Surveys (Friz, 2018). These existing measures are backward-looking or dispersion-based, and their object of reference – to which survey participants are supposed to relate their uncertainty – is either generic or not defined at all. My measure of uncertainty closes this gap as a forward-looking, first-order measure that participants

[2] Bartik et al. (2020) provide broad and descriptive evidence on the effect of the pandemic on small businesses in the US. Brülhart et al. (2020) provide similar evidence for self-employed in Switzerland. Using another survey on Swiss firms, Zoller-Rydzek and Keller (2020) show that firms' decrease in business activity is driven by a decline in foreign demand. Baker et al. (2020) document an enormous increase in survey-based expectation uncertainty of firms at the onset of the crisis in the US and the UK. Balleer et al. (2020) study price-setting behavior in German firm-level survey data.

[3] Proxies for irreversibility include, for instance, the ratio of fixed to total assets (Gulen and Ion, 2016), asset redeployability (Kim and Kung, 2013), or asset irreversibility derived from firms' depreciation rate (Chirinko and Schaller, 2009). Proxies of macro-level uncertainty include the volatility of the stock market (Bloom, 2009; Bekaert et al., 2013; Barrero et al., 2017), disagreement among professional forecasters (Boero et al., 2008; Bachmann and Bayer, 2013, 2014; Baker et al., 2016), mentions of "uncertainty" in newspapers and other text sources (Baker et al., 2016; Hassan et al., 2019; Handley and Li, 2020), and prediction errors derived from econometric models (Fernández-Villaverde et al., 2011; Jurado et al., 2015). Proxies of firm-level uncertainty include the dispersion of firms' expectations (Guiso and Parigi, 1999) and ex-post forecast errors (Bachmann et al., 2013).

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relate directly to their investment expectations.
Finally, it adds to the strand of the literature that examines the influence of financial constraints on firms' investments by highlighting the importance of firms' financial situation and profitability during the recent crisis. My results align with the extensive literature highlighting the adverse effect binding financial constraints on firms' investments (see, for example, Bernanke et al., 1996; Fazzari et al., 1988).

The remainder of this paper is organized as follows. Section 2 provides an overview of the onset of the COVID-19 pandemic in Switzerland in the first half of 2020. Section 3 describes the data. Section 4 lays out the empirical strategy. Section 5 presents the results. Section 6 provides robustness analyses. Section 7 concludes.

2 The COVID-19 pandemic in Switzerland

Aside from its impact on public health, the COVID-19 pandemic and the measures to contain it have triggered economic crises worldwide. In many countries, public and social life was essentially shut down as part of ordered mass quarantines ("lockdowns"). As a result, businesses were forced to close, curfews imposed, and contact restrictions put in place, without a clear perspective of how and when the situation would be back to normal.

In Switzerland, coronavirus disease first caught public attention on 8 January 2020, after a newspaper reported multiple cases of mysterious lung disease in Wuhan's central Chinese metropolis (Neue Zürcher Zeitung, 2020). On 14 February, France announced the first coronavirus death in Europe. On 22 February, neighboring Italy confirms a major outbreak as it detects a cluster of cases in Lombardy. On 25 February, for the first time, a Swiss resident tested positive for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the virus causing COVID-19. The first death related to COVID-19 in Switzerland was confirmed on 5 March. In the following weeks, the virus spread quickly around the country, such that daily counts of newly confirmed cases grew exponentially, see Figure 1.

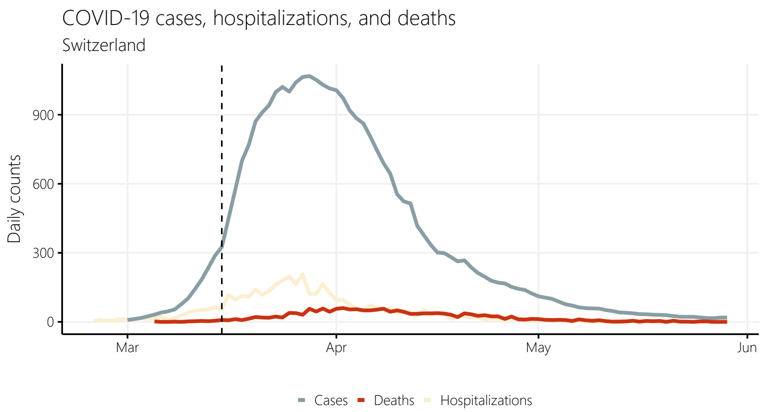

Figure 1: This chart shows daily numbers of confirmed COVID-19 cases by diagnosis date, hospitalizations due to COVID-19 by admission date, and deaths by date of death from COVID-19 on a daily basis for Switzerland for the duration of the investment survey in spring 2020 (i.e., from 25 February to 31 May 2020). Counts are shown as 7-day right-aligned moving averages. The vertical dashed line marks the declaration of the "extraordinary situation" by the Swiss Federal Council on 16 March 2020.

Despite the comparatively high prevalence of positive cases, the local and national authorities initially

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adopted only relatively mild measures.[4] On 28 February 2020, the Federal Council classified the state of affairs in Switzerland as a “special situation” under the Epidemics Act[5] and prohibited, among other things, events involving more than 1000 people. The Swiss Federal Office of Public Health launched an information campaign on 1 March. On 13 March, the Federal Council prohibited events with more than 100 people and closed public schools as of 16 March.

Only a few days later, on 16 March, the Federal Council reclassified Switzerland’s situation fundamentally and declared an “extraordinary situation” in terms of the Epidemics Act.[6] Faced with the rapidly evolving epidemiological situation, the Swiss government decreed a partial lockdown and introduced nation-wide measures to protect the public. These entailed mobility restrictions, social distancing rules, and shop closures. Non-essential retail outlets and many service providers (such as restaurants, bars, and entertainment and leisure facilities) were to close. Only a few essential industries, such as grocery stores, pharmacies, banks, and post offices, were exempt from the measures and allowed to remain open. All public and private events were prohibited. Besides, the government called on the public to avoid unnecessary contact and keep their distance from others. Wherever possible, work activities were to be carried out from home. Where this was not possible and where hygiene measures could not be respected, work activities had to be stopped. Beyond, border controls were introduced, and entry bans were imposed.

The announcement of an “extraordinary situation” and the adoption of far-reaching measures proved to be a focal point adding an economic dimension to the crisis, which had hitherto been epidemiological exclusively. Private consumption declined sharply.[7] Business activity was widely restricted, and firms’ outlook for the future severely clouded. Many companies suffered a significant or even complete loss of sales and faced liquidity problems. Employees were put on short-time work or laid off altogether. At the time, GDP was projected to contract by more than 5% over the whole year (KOF, 2020; SECO, 2020).

The measures announced on 16 March were effective immediately and until 19 April at first. On 8 April[8], the Federal Council extended the measures by one week until 26 April. At the same time, it decided to ease the measures in April gradually. However, it would not decide on the steps to ease the measures until its next meeting on 16 April.

One month into the lockdown, the Federal Council presented its roadmap to ease the lockdown measures on 16 April, given the encouraging epidemic development.[9] The reopening of the economy and public life should take place in three stages. In an initial phase commencing on 27 April, hairdressers, beauty salons, DIY stores, flower shops, and garden centers were allowed to reopen. Also, from 27 April, hospitals were again allowed to perform all operations. In phase two, commencing on 11 May, compulsory schools and retail shops were allowed to reopen. In phase three, set to commence on 8 June, secondary schools and universities, museums, zoos, and libraries were to reopen.

These three stages were effectively met. By announcing its schedule for the further easing of lockdown measures up to the start of June, the Federal Council aimed to show both households and firms a clear perspective out of the crisis and create planning reliability. This was lacking during the one-month lockdown, which contributed to the unprecedented rise in uncertainty. The further course of the pandemic

[4]See Appendix A for a more detailed timeline of selected events and measures taken by the Swiss federal government in the onset of the COVID-19 pandemic in Switzerland.

[5]The Epidemics Act is a federal law of the Swiss Confederation on the control of transmissible human diseases. It was adopted in its current form by the Federal Assembly on 28 September 2012, after being examined by the Federal Council on 3 December 2010. The law was submitted to a popular vote in an optional referendum. With a turnout of just under 47 percent, the law was adopted on 22 September 2013, with 60 percent of the vote in favor. It is in force since 1 January 2016. The special and extraordinary situations it sets out, and the additional powers for the executive branch that they entail were first proclaimed during the COVID-19 pandemic.

[6]For further information, see the press release by the Swiss Federal Council (2020a).

[7]In Seiler (2020b), I use public data from debit card transactions to measure COVID-induced changes in consumer spending and quantify the resulting weighting bias in Swiss consumer price inflation.

[8]For further information, see the press release by the Swiss Federal Council (2020b).

[9]For further information, see the press release by the Swiss Federal Council (2020c).

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and the policy response were challenging to anticipate. Between 16 March and 16 April, it was generally unknown how long the imposed measures would be maintained and how long the overall lockdown would last. Both the measures and their relaxation depend on how the epidemic develops – the virus sets the pace. As a result, prospects for the future were very limited and uncertainty exceptionally high.

These circumstances constitute an ideal study ground to examine how firms adjust their investment expectations in response to a substantial exogenous shock and how various determinants of firms' investments play in them.

3 Data

To examine the pandemic's effects on firms' investment plans, I use firm-level data from the investment survey[10] conducted by the KOF Swiss Economic Institute at ETH Zurich. Since 2012 in spring and autumn, this survey is conducted bi-annually among a large panel of private Swiss firms collecting detailed information on investment decisions and plans. Currently, it consists of 13,287 firms. The average response rate between 2012 and 2020 amounts to 29%. The sampled firms cover all industries, except agriculture, and account for 58% of total employment (FTE) in Switzerland. Appendix B describes the survey in greater detail.

3.1 Measuring revisions of firms' investment plan

The investment survey is focused on quantitative information on planned and realized investment. For this purpose, every survey asks firms about their investments for several years. In autumn, firms report on their investments for the past, current, and following year. In spring, they report on their investments for the current year and the two previous years. Thus, for a firm participating every spring and autumn, the survey collects six investment figures for any given year at different points in time, as illustrated by Figure 2. The area highlighted in yellow represents an example of the six investment amounts collected for 2019, the first in the 2018 autumn survey and the last in the 2021 spring survey. Some of the investment data are *actual* (i.e., realized) investments made in the past; some refer to *planned* investments in the future.

The survey asks firms to state their investments separately for investments in equipment and machinery[11], construction[12], and research and development (R&D)[13]. It defines gross fixed capital formation (GFCF) as the sum of the three categories. Beyond these investment categories, the survey asks whether investments serve to replace capital, extend production capacity, or streamline production. Firms may choose one or more of these purposes.

The reporting and data structure reveals changes in firms' investment plans at three points in time over one and a half years. For the analysis, one change in investment expectations is of particular interest. The survey allows quantifying the revisions of firms' investment plans during the COVID-19 pandemic. For the year 2020, we observe a company's expected investments both in autumn 2019 ($I_{i,t=2020,s=\text{autumn 2019}}$) and spring 2020 ($I_{i,t=2020,s=\text{spring 2020}}$). The revision of the investment plan of

[10] Recent studies using the investment survey have analyzed the effects of exchange rate uncertainty (Bannert et al., 2015; Binding and Dibiasi, 2017), economic policy uncertainty (Dibiasi et al., 2018), or the low-interest-rate environment (Seiler, 2020a) on firms' investment activity.

[11] Investments in equipment and machinery include machinery, mechanical equipment, conveying and warehouse equipment, office machines incl. IT (hardware and software), furniture, vehicles used for business purposes, and services that have the maintenance, improvement, or renewal of installations as their purpose.

[12] Investments in construction include new construction, reconstruction, and renovation of industrial and commercial buildings.

[13] Investments in research and development include the costs of the company's own research projects, such as personnel costs and materials and equipment to support research and development, as well as costs for purchased research and development services or costs for the purchase of patents.

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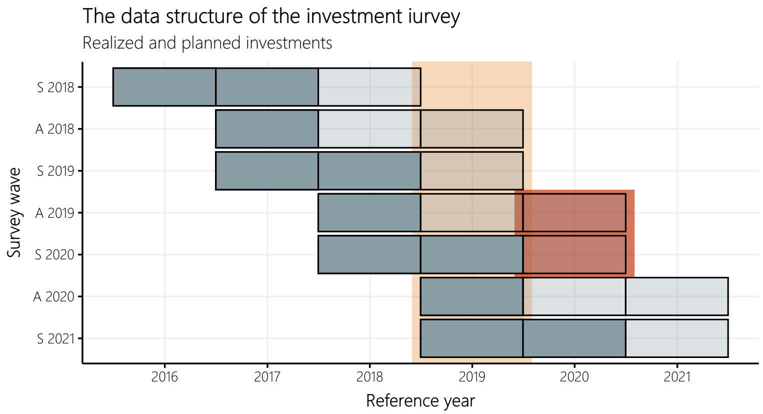

Figure 2: Reporting and data structure of the quantitative questions from the investment survey conducted by the KOF Swiss Economic Institute at ETH Zurich. Dark shaded areas represent realized investments. Light areas represent planned investments. The area highlighted in yellow represents the six investment amounts collected for 2019 as an example. The area highlighted in red the change in investment expectations of particular interest, namely the change in expected investment for 2020 between autumn 2019 and spring 2020.

firm i for the year $t = 2020$ then results from the between-wave change in planned investments (see the red highlighted area in Figure 2), i.e.

$$\Delta I_{i,t=2020} = \log(I_{i,t=2020,s=\text{spring 2020}}) - \log(I_{i,t=2020,s=\text{autumn 2019}}). \tag{1}$$

Investment revisions defined in this way will serve as dependent variables in the regression analyses. Since the logarithm of zero is not defined, about 12.7% of all firm-year observations are discarded. Conditioning the sample to firms with positive investment does not induce a sample selection bias in my analysis, as I show in Section 6 and Appendix C.3.

Using the investment surveys conducted since autumn 2013, I construct a firm-level panel data set providing yearly data on firms' investment revisions for 2014-2020. In the final data set, I only retain companies whose 2020 investment revisions can be calculated, i.e., firms that reported investment figures for 2020 both in autumn 2019 and spring 2020. Besides, I exclude all paper survey participants and only retain the answers of those participants who completed the survey online.[14] This allows me to determine the exact time of response, which will prove necessary for identification as part of the empirical strategy (see Section 4).

3.2 Explaining revisions of firms' investment plan

How did the COVID-19 pandemic affect firms' investment decisions? I answer this question by considering a broad array of determinants of investments, namely a firm's exposure to the virus intensity, its sensitivity to the lockdown and government-imposed measures, uncertainty with its effect on irreversible investment, as well as demand, financial and technological factors.

[14] In Appendix B, I compare online and paper survey respondents by selected firm characteristics. As a robustness check in Appendix C.3, I further show that the exclusion of paper respondents does not affect my main results.

Exposure to virus intensity

A key metric of the COVID-19 crisis is the spread of the virus, which in Switzerland has spread very differently from region to region. Figure 3 displays the number of confirmed COVID-19 cases by canton per 100,000 inhabitants by the end of the spring survey (30 May 2020). While there were particularly many cases in the Southern parts of Switzerland (Ticino and Lake Geneva Region), the pandemic was significantly less advanced in the cantons of Central or Eastern Switzerland.

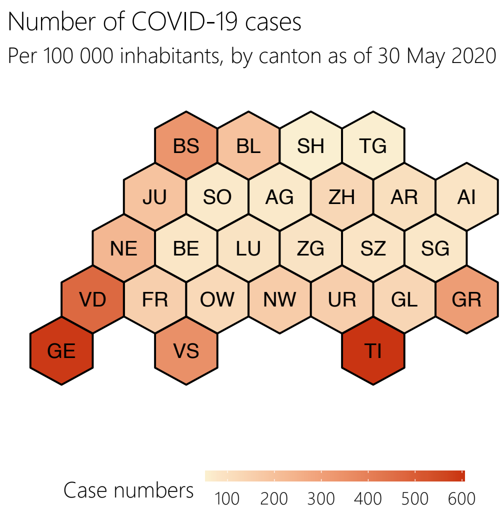

Figure 3: Number of COVID-19 cases by canton per 100,000 inhabitants by the end of the investment survey in spring 2020 (30 May 2020).

Firms in regions with higher virus intensity may be inclined to take stronger operational measures to manage the pandemic's economic consequences than firms in regions with lower virus intensity. Therefore, investment revisions may be related to the regional differences in the spread of the virus, reflecting the local severity of the pandemic. To measure virus intensity, I use the cumulative numbers of confirmed COVID-19 cases and fatalities (as a percentage of the cantonal population) by canton at the spring 2020 investment survey (30 May 2020). I obtain both measures from the Swiss Federal Office of Public Health and match them to firms by cantons in which they are legally registered.

Sensitivity to lockdown and government-imposed restrictions

Another reason for investment revisions may be related to the government's restrictions to contain the pandemic. To assess firms' sensitivity to the lockdown measures, I resort to two auxiliary metrics: a lockdown index, which is based on an occupation's dependence on physical proximity, and a home office index, which is based on an occupation's ability to do work from home.

Faber et al. (2020) construct the lockdown index for Switzerland using the Occupational Information Network (O*NET) survey questions about physical proximity requirements. The index classifies an occupation as restricted from lockdown if it involves a small physical distance from other people. Hence, the lockdown index measures whether an occupation is limited or restricted during the lockdown and how difficult it is for different occupations to comply with the hygiene rules after the relaxation of the lockdown measures. It also takes into account that some essential sectors are excluded from the federal measures. The index ranges from zero to one. A value of zero means that the occupation does not rely

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on physical proximity. A value of one means that physical proximity is essential.

Faber et al. (2020) also build the home office index for Switzerland using the O*NET survey. The index captures an occupation's ability to do work from home and, therefore, can be seen as an alternative measure of firms' sensitivity to lockdown measures. It ranges from zero to one. A value of zero means that workers cannot work from home. A value of one means that workers can do their tasks from home.

Figure 4 visualizes both the lockdown index (in the left panel) and the home office index (in the right panel) together with the share of firms surveyed in the investment survey by industry.

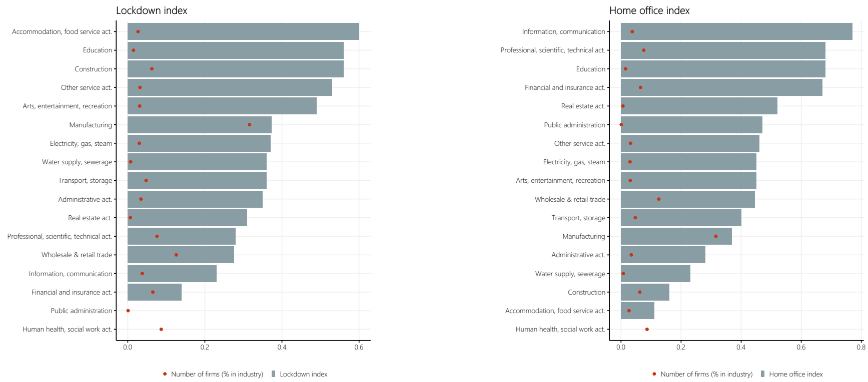

Figure 4: Lockdown index (left panel) and home office index (right panel) together with the share of firms surveyed in the investment survey by industry. The values for both the lockdown index and the home office index are taken from Faber et al. (2020).

Both the lockdown index and the home office index are exogenous in the sense that both an occupation's dependence on physical proximity and its ability to do work from home cannot easily (or rapidly) be altered. I obtain both indices by industry (NOGA 2008) and match them to firms by industries in which they operate.

Firm-level uncertainty

As a first of more general determinants of investment, I consider uncertainty. The idea that investment decisions are sensitive to investors' perceived uncertainty is not new. Many economic decisions involve an intertemporal element in that the moment of decision-making and its realization are separated in time. Because the future is unknown, companies face uncertainty when making decisions. Higher uncertainty is then thought to impair firms' ability to form reliable expectations, making it harder to make investment decisions.

Uncertainty is a broad and amorphous concept (Bloom, 2014). It is amorphous as it concerns consumers, managers, and policymakers alike. It is broad as it covers both micro (e.g., investment projects of firms) and macro (e.g., refinancing interest rate) phenomena as well as non-economic events (e.g., COVID-19 pandemic). The modern concept of uncertainty dates back to Knight (1921), who defined uncertainty as peoples' inability to forecast the likelihood of events.[15]

According to this definition, uncertainty cannot be observed directly. Therefore, the economic literature has developed several different strategies to operationalize uncertainty through a broad range of proxy measures. Proxies of macro-level uncertainty include the volatility of the stock market (Bekaert et al., 2013), disagreement among professional forecasters (Boero et al., 2008; Bachmann et al., 2013; Baker

[15]In this paper and following general practice, I use a broad concept of uncertainty, which encapsulates both risk and Knightian uncertainty.

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et al., 2016), mentions of "uncertainty" in newspapers and other text sources (Baker et al., 2016; Hassan et al., 2019; Handley and Li, 2020), and prediction errors derived from econometric models (Bloom, 2009; Fernández-Villaverde et al., 2011; Jurado et al., 2015). Proxies of firm-level uncertainty include the dispersion of firms' expectations (Guiso and Parigi, 1999) and ex-post forecast errors (Bachmann et al., 2013).

I identify uncertainty at the firm level using a survey question in every wave of the investment survey since spring 2015. This question concerns how confident firms are about realizing their future investment plans.[16] It asks firms to classify their implementation certainty on a 4-item Likert scale as "very certain," "fairly certain," "fairly uncertain," or "very uncertain."

Figure 5 displays the distribution of the reported certainty of realization by all the firm-year observations in the sample.

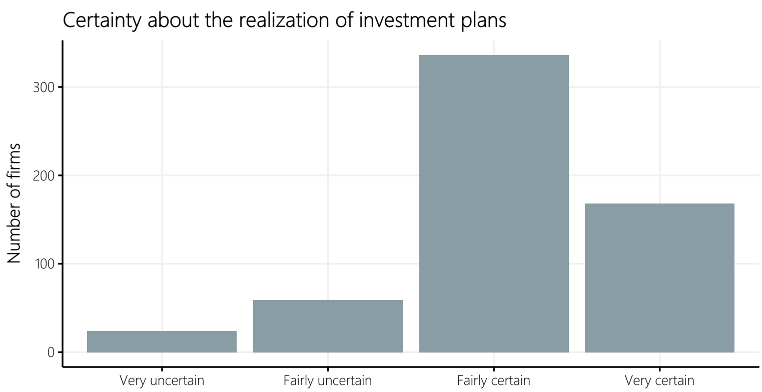

Figure 5: Distribution of firms' certainty of realization of their investment plans for the current year over the pooled sample. 3% of firms report that they are very uncertain. 11% of firms report that they are fairly uncertain. 62% of firms answer that they are fairly certain. 24% of participating firms state that they are very certain.

The overwhelming majority of firms indicate at least some certainty about the realization of their investment plans. By contrast, only 3% of the firms state that their plans are very uncertain.

For the analysis, I convert this survey question about firms' certainty into a measure of firms' uncertainty by encoding the categorical answer choices into numbers and inverting their scale. In that way, the resulting firm-level uncertainty measure is a time-varying, ordinal variable ranging from -2 (corresponding to "very certain") to 2 (corresponding to "very uncertain").

$$\text{Uncertain}_{i,t} = \begin{cases} 2 & \text{if firm } i \text{ in } t \text{ is very uncertain} \\ 1 & \text{———''——— fairly uncertain} \\ -1 & \text{———''——— fairly certain} \\ -2 & \text{———''——— very certain} \end{cases} \tag{2}$$

This firm-specific measure of uncertainty has several advantages over the proxies typically employed in the literature. Unlike dispersion-based proxies, it is a first-order measure. Usually, survey-based uncertainty measures are proxied by the dispersion of firms' expectations about the future. This approximation is based on the assumption that, in times of high uncertainty, firms' assessments of the future are more

[16] In autumn, the survey assesses the certainty of realization of the investment plans for the next year. In spring, the survey assesses the certainty of realization of the investment plans for the current year.

disperse than in times of low uncertainty, when most decision-makers' assessments are roughly the same. Dispersion-based measures, however, suffer from a significant weakness: Beyond uncertainty, survey data dispersion is also influenced by the heterogeneity of firms and their genuine disagreement (Girardi and Reuter, 2016).

Also, the object underlying dispersion-based measures of uncertainty is often not precisely determined. This is different from my uncertainty measure, which refers to firms' investment uncertainty specifically. Most of the earlier studies that have examined the effect of uncertainty on firms' investments have either employed uncertainty measures with very specific objects not directly related to investments (e.g., output price uncertainty (Hartman, 1972; Abel, 1983; Abel and Eberly, 1997), demand uncertainty (Caballero, 1991), or profit uncertainty (Abel and Eberly, 1994)) or combined an array of different variables of firms' expectations at the cost of a lack of transparency and determinacy. My study contributes to this long-standing literature in that it more explicitly identifies firms' investment uncertainty.

Conversely, the source of uncertainty captured by the measure remains undetermined by choice. This invites firms to consider a broad and individual range of factors that influence their investment decisions. At the same time, firms will only consider sources that are relevant to them. By contrast, survey-based proxies of uncertainty only ever draw from a bounded set of factors. For instance, an uncertainty measure derived from demand expectation only identifies those factors as sources of uncertainty that also influence demand. Finally, the measure is based on the assessment of either the owner of the firm or a member of its top management. This ensures that the measure reflects someone's assessment with informed knowledge and direct responsibility for the firms' investment decisions. In this respect, my measure is similar to the one employed by Guiso and Parigi (1999). However, their measure was not time-varying.

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Firm-level investment irreversibility

The economic theory highlights different channels through which uncertainty affects investment, with one of the most prominent channels revolving around "real options.[17] Real options theory (Bernanke, 1983; Pindyck, 1988; Caballero, 1991) describes firms' investment choices as a series of options. If uncertainty increases, firms resort to wait-and-see behavior until more information becomes available to inform their decision. Until then, firms postpone their investment plans. Alternatively, when uncertainty is high, the option value of delaying investments is high. Real options, however, are not universal. They require investment to be irreversible for uncertainty to affect investment. After all, reversible investment does not lead to the loss of an option.

Irreversible investments in uncertain environments are common in many industries: Swiss Federal Railways must construct train tracks before knowing how frequent travelers will use a new connection. Novartis must initiate R&D processes before knowing whether its researcher will find an effective vaccine. Swatch must sink costs into the design of new watches before orders from customers come in.

To infer the degree of irreversibility of firms' investments, the investment survey since spring 2015 contains a question inspired by Guiso and Parigi (1999). It asks about the second-hand market conditions for existing equipment and machinery. Firms can choose from four options: (1) there exists a second-hand market, and it is relatively easy to find a buyer in a short time willing to pay a reasonable price; (2) there exists a second-hand market, but it takes time to find a buyer and selling prices are not very rewarding; (3) even though there exists a second-hand market, it is very difficult to find a buyer and selling prices can be very low; and (4) there does not exist a second-hand market for the existing machinery and

[17] Overall, the effects of uncertainty on investment decisions explained by these channels are ambiguous. Theoretical channels that explain negative investment effects from uncertainty include borrowing constraints due to higher risk premia (Gilchrist et al., 2014; Christiano et al., 2014; Arellano et al., 2019), and a loss of confidence caused by ambiguity aversion (Hansen et al., 1999; Ilut and Schneider, 2014). Theoretical channels that explain positive investment effects from uncertainty include growth options (Bar-Ilan and Strange, 1996; Stein and Stone, 2013; Kraft et al., 2018) and the Oi-Hartman-Abel (Oi, 1961; Hartman, 1972; Abel, 1983) effect.

production plants.

Figure 6 displays the distribution of the reported irreversibility by all the firm-year observations in the sample.

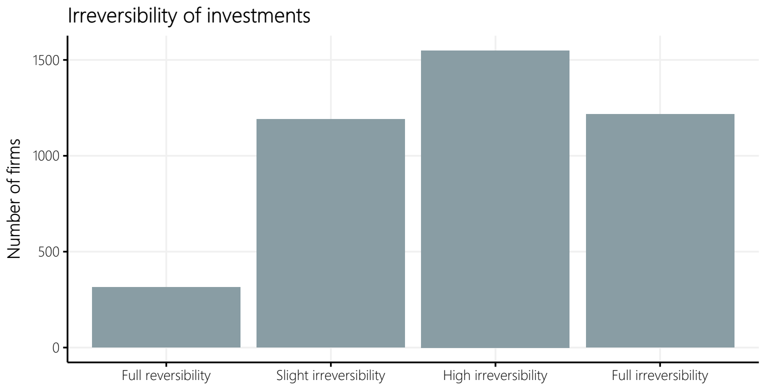

Figure 6: Distribution of the firm-specific irreversibility of investments over the pooled sample. Firms are asked about the second-hand market conditions for their existing machinery and production plants. 7% of firms report that there exists a second-hand market and that it is relatively easy to find a buyer in a short time willing to pay a reasonable price (full reversibility). 28% of firms report that there exists a second-hand market, but it takes time to find a buyer, and selling prices are not very rewarding (slight irreversibility). 36% of firms answer that even though there exists a second-hand market, it is very difficult to find a buyer, and selling prices can become very low (high irreversibility). 29% of participating firms state that there exists no second-hand market for their existing machinery and production plants (full irreversibility).

Almost two-thirds of all firms report at least some degree of irreversibility. Only 7% of the firms indicate complete reversibility.

For the analysis, I transform the 4-item Likert scale of the survey question into a binary variable of irreversibility. The variable takes a value of 1 in the case where a firm reports that there does not exist a second-hand market ("full irreversibility"), or it is very difficult to find a buyer and selling prices can be very low at the existing market ("high irreversibility"):

$$\text{Irreversible}_{i,t} = \begin{cases} 1 & \text{if firm } i \text{ in } t \text{ reports high or full irreversibility} \\ 0 & \text{otherwise} \end{cases} \tag{3}$$

Demand, financial resources, and technological factors

Furthermore, I use firm-level data on the influence of demand, financial resources, and technological factors on firms' planned investments. In more detail, these factors comprise demand trends (such as capacity utilization and expected changes in sales or prices), financial resources (such as expected profits, availability and cost of credit, or return on investment), and general technological development. Every autumn wave of the investment survey asks firms to rate the influence of each factor on their investment planned for the next year on a scale from very limiting to very stimulating.

3.3 Sample summary and descriptive statistics

The final data set covers 1,200 different firms. Table 1 reports the summary statistics of the most important variables used in the paper. The average firm size is 374 FTE workers. About 33% of all firms

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are in the manufacturing sector; the share of firms in the service sector is 57%. Investment revisions are, on average, small and close to zero. They amount to 1.8% for GFCF, −0.9% for equipment, −0.4% for construction, and −0.8% for R&D. The average investment is 13.4 log points (660,000 CHF) with a standard deviation of 2.6. The moments indicate that the distribution of investments has a long right tail, with a small set of firms planning huge investment projects.

Overall, these survey data have several properties that are desirable for my research design. First, they include not only realized investments but also planned investments. Investment expectations are fundamental to study investment decisions and reveal the role of uncertainty as part of this process. However, because this information is difficult to access, only a few studies to date have used data on planned investments (e.g., Guiso and Parigi, 1999; Binding and Dibiasi, 2017; Bachmann et al., 2017). More easily accessible are actual investment data based on annual accounting results (e.g., Leahy and Whited, 1995; Bloom et al., 2007; Kang et al., 2014; Gulen and Ion, 2016).
Second, besides qualitative data, the survey also collects quantitative data on firms' investments. Previous studies that have surveyed firms' investment plans (e.g., Gennaioli et al., 2016; Coibion et al., 2018; Altig et al., 2020), have done so in a qualitative manner (e.g., "do you expect investments to rise, fall, or stay the same in the next 12 months?"), which makes it difficult to extract quantitative measures of investment expectations (Bachmann and Elstner, 2015). In contrast, I collect quantitative answers from firms about the amount of both the investments they have made in the past and the investments they plan to make in the future.
Third, many firms' repeated survey over a long period has created a panel with Large-N and Large-T properties. This feature allows me to study the evolution of firms' investment plans along the entire decision-making process: I observe firms' initial expectations one year in advance, I watch them change and materialize over time, and I capture the final investment decision that firms eventually make.
Forth, the survey covers a wide range of firms, from small to large and across all industries in Switzerland, except agriculture. Often, quantitative investment surveys either consider only large firms[18] or cover only one sector of the economy[19].
Finally, in addition to investment data, the survey collects firm-specific information on various factors that influence firms' investment activity, including uncertainty, demand, or technological and financial factors. This allows exploring how firm-specific and time-varying factors like these influence firms' investment decisions.

4 Empirical strategy

4.1 Identification

I use a quasi-experimental research design to determine the causal effect of the COVID-19 pandemic on firms' investment plans. In particular, I identify the COVID-induced effect on firms' investments by comparing the revision of the 2020 investment plans of companies that in spring 2020 responded before the crisis with those of companies that responded during the crisis using difference-in-differences estimations.

I divide firms accordingly into two groups. Firms that completed the investment survey in spring 2020 before 16 March belong to the group that responded before the crisis (control group). All others are part of the group that responded during the crisis (treatment group). Hence, I construct a binary variable

[18] For instance, Bloom et al. (2007) study the investment behavior of a sample of 672 publicly traded UK firms.
[19] Investment surveys are most often limited to the manufacturing sector, e.g., Guiso and Parigi (1999); Fuss and Vermeulen (2008); Bachmann et al. (2017); Bachmann and Zorn (2020).

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	N	Mean	Std. Dev.	Minimum	0.10 decile	0.25 decile	Median	0.75 decile	0.90 decile	Maximum
Investment revisions (GFCF)	3755	0.02	0.73	-11.51	-0.69	-0.19	0.00	0.25	0.69	7.42
Investment revisions (equipment)	3482	-0.01	0.59	-4.40	-0.69	-0.22	0.00	0.23	0.69	2.38
Investment revisions (construction)	1868	-0.00	0.66	-2.71	-0.71	-0.22	0.00	0.22	0.73	3.00
Investment revisions (R&D)	1011	-0.01	0.56	-3.56	-0.69	-0.14	0.00	0.15	0.69	2.30
Manufacturing firm	6448	0.33	0.47	0.00	0.00	0.00	0.00	1.00	1.00	1.00
Construction firm	6448	0.06	0.24	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Service firm	6448	0.57	0.50	0.00	0.00	0.00	1.00	1.00	1.00	1.00
Number of FTE	6139	373.50	1764.45	1.00	6.00	20.00	74.00	226.65	676.40	41632.00
Large firm (1 if more than 250 FTE)	6448	0.27	0.44	0.00	0.00	0.00	0.00	1.00	1.00	1.00
Firm age	3637	71.53	46.85	4.00	23.00	37.00	61.00	98.00	129.00	485.00
Exporter (1 = Yes, 0 = No)	4680	0.33	0.47	0.00	0.00	0.00	0.00	1.00	1.00	1.00
COVID cases	6433	0.32	0.26	0.09	0.15	0.16	0.23	0.33	0.93	1.03
COVID deaths	6433	0.02	0.02	0.00	0.00	0.01	0.01	0.02	0.05	0.09
Lockdown index	6440	0.32	0.15	0.00	0.14	0.24	0.34	0.40	0.56	0.71
Home office index	5929	0.43	0.19	0.11	0.16	0.24	0.41	0.60	0.68	0.77
Irreversibility (1 = Yes, 0 = No)	4887	0.35	0.48	0.00	0.00	0.00	0.00	1.00	1.00	1.00
Uncertainty (1 if very/fairly uncertain)	4917	0.14	0.35	0.00	0.00	0.00	0.00	0.00	1.00	1.00
Employee education	3548	0.05	0.22	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Personnel expenses	3460	0.21	0.41	0.00	0.00	0.00	0.00	0.00	1.00	1.00
ICT	2404	0.26	0.44	0.00	0.00	0.00	0.00	1.00	1.00	1.00
E-commerce	1592	0.08	0.28	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Factor technology	4621	0.03	0.17	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Factor finance	4742	0.16	0.37	0.00	0.00	0.00	0.00	0.00	1.00	1.00
Factor demand	4722	0.10	0.30	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Purpose replacement	4111	0.25	0.43	0.00	0.00	0.00	0.00	1.00	1.00	1.00
Purpose extension	2290	0.35	0.48	0.00	0.00	0.00	0.00	1.00	1.00	1.00
Purpose streamlining	2920	0.23	0.42	0.00	0.00	0.00	0.00	0.00	1.00	1.00
Purpose environment	1893	0.27	0.44	0.00	0.00	0.00	0.00	1.00	1.00	1.00

Table 1: This table provides summary statistics for the variables used in estimations. The table provides averages for firm-year observations for the period 2014-2020.

that considers a firm as exposed to the COVID-19 pandemic as follows:

$$\text{COVID}_i = I[t_i \geq 16 \text{ March } 2020] = \begin{cases} 1 & \text{if } t_i \geq 16 \text{ March } 2020 \\ 0 & \text{if } t_i < 16 \text{ March } 2020 \end{cases} \quad (4)$$

I choose 16 March as the cut-off date, when the Federal Council declared the "extraordinary situation" and decreed far-reaching measures to contain the further spread of the virus and protect the public.

Credible identification of the effect of the COVID-19 crisis on firms' investments hinges on this choice of the treatment date. It is clear that from an epidemiological point of view, the crisis was already well advanced before 16 March. However, only the policy response of that day proved to catalyze the economic dimension of the crisis. This claim – and with it the validity of the identification strategy – essentially rests on two assumptions. First, there were no fundamental economic reactions to the crisis before 16 March. Second, the public did not anticipate the policy measures announced on 16 March. I provide evidence to support both assumptions in Figure 7 and Figure 8.

Figure 7 displays daily averages of the current business situation as reported by the firms[20] themselves in the KOF business tendency survey, in which firms are asked to assess their overall business situation as either "good," "satisfactory," or "poor." "Business situation" is a deliberately holistic term, chosen as an umbrella term to reflect firms' overall economic conditions and essential business determinants such as turnover, profits, costs, and liquidity. The advantage of a soft question like this is that it can be asked in all economic sectors, and the participants themselves choose the factors most relevant for them. It thus gives a quite differentiated view of economic development and can be regarded as a coincidence indicator.

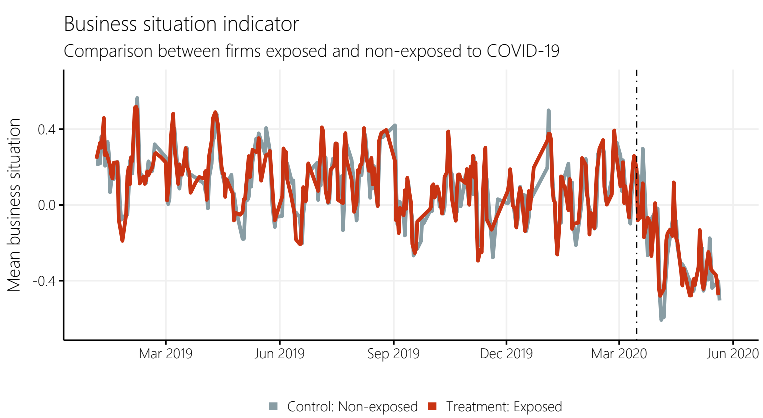

Figure 7: Daily averages of the current business situation as reported in the KOF business tendency surveys, separately for firms in the treatment and control group. The KOF business tendency survey asks firms to assess their current overall business situation as either "good," "satisfactory," or "poor," where "good" is coded as 1, "satisfactory" as zero, and "poor" as −1. To increase readability, I display the centered moving average of the daily means with a window length of 7 days. The vertical dotted line marks the declaration of the "extraordinary situation" by the Swiss Federal Council on 16 March 2020.

Figure 7 corroborates two points. First, there is no significant difference in firms' assessment of their current overall business situation depending on whether they belong to the treatment or control group. Both before and after 16 March, the two lines are virtually identical. Second, the policy measures

[20]Business tendency surveys track firms over time and monitor a variety of relevant business determinants. The KOF business tendency survey covers all sectors represented in the investment survey, although they are not conducted with the same set of firms. The figure shows the current business situation for the overlap of firms participating in both surveys in spring 2020, which is 453 firms.

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announced on 16 March had a substantial impact on firms' business situation. This holds for both groups of firms. What is more important, while most firms have assessed their business situation as "good" or "satisfactory" before the crisis, it started to deteriorate significantly only after 16 March in the wake of the pandemic. Since 16 March 2020, firms have, on average, classified their business situation rather as "poor" than "good."

Figure 8 underscores that people did not anticipate the policy measures announced on 16 March. It shows daily data on the intensity of internet search queries for economic, policy- and disease-related terms on Google in Switzerland between 1 January and 31 May 2020. The increasing importance of the internet as a primary source of information makes internet search queries indicative of people's interests and concerns (Choi and Varian, 2012; Bontempi et al., 2016). The data can be retrieved from Google's website, allowing users to query the relative popularity of search terms for selected geographical regions and periods. Notably, interest in search terms over time is reported as an index. The values indicate the search interest relative to the highest point in the diagram for the selected region in the specified period. The value 100 represents the highest popularity of the search terms. A value of 50 means that the term is half as popular, and a value of 0 means that not enough data was available for this term.

Figure 8 displays the relative frequencies of search queries with some of the most relevant economic, disease- and policy-related keywords. It underpins three things. First, the public had been aware of the coronavirus disease since late January 2020 (first panel). The increasing spread of the virus in the immediate vicinity and the first cases in Switzerland have significantly increased the frequency of searches in late February and early March. Second, immediate economic reactions to the early spread of the virus seem to have failed to materialize (second panel). Relevant search terms that indicate a negative economic sentiment only peak immediately after 16 March. Third, the public did not anticipate the measures taken on 16 March (third panel). Before introducing the Swiss lockdown, there were virtually no search queries that would hint at that policy response. Hence, when the companies in the control group participated in the survey, neither the extent of the crisis nor the Swiss government's measures seem to have been in any way foreseeable.

Figures 7 and 8 support the validity of my identification strategy, according to which 16 March marks the beginning of the COVID-induced economic crisis in Switzerland. The announcement of the "extraordinary situation" proved to be a focal point that added an economic dimension to the crisis, which had hitherto been epidemiological exclusively. Thus, 16 March is a plausible cut-off date for classifying survey respondents in spring 2020 into treatment and control groups.[21] This allows me to calculate the revisions of firms' investment plans separately for the two groups of firms and to interpret any difference between them causally as COVID-induced effect.

4.2 Methodology and regression model

Formally, I investigate the influence of the COVID-19 shock on firms' investment plan revisions by estimating variants of the following difference-in-differences (DD) regression model:

$$\Delta I_{i,t} = \gamma_j + \delta_k + \alpha_1 T_t + \alpha_2 \text{COVID}_i + \alpha_3 T_t \cdot \text{COVID}_i + \beta \mathbf{X_{i,t}} + \varepsilon_{i,t} \tag{5}$$

The DD model compares the change in investment plans of companies that completed the survey in spring 2020 during the pandemic with the change in investment plans of companies that in spring 2020

[21] In Section 6, I provide robustness checks of the main analysis by altering the treatment date. In particular, I choose 28 February (declaration of the "special situation"), 1 March, and 5 March (first COVID-related death in Switzerland) as alternative treatment dates. In a further specification, I exclude all firms participating in the survey between 1 March and 16 March and assign the respondents after 16 March to the treatment group. This specification aims to make the estimation independent of any choice of the treatment date. In all alternative specifications, the main results remain significant and qualitatively unchanged.

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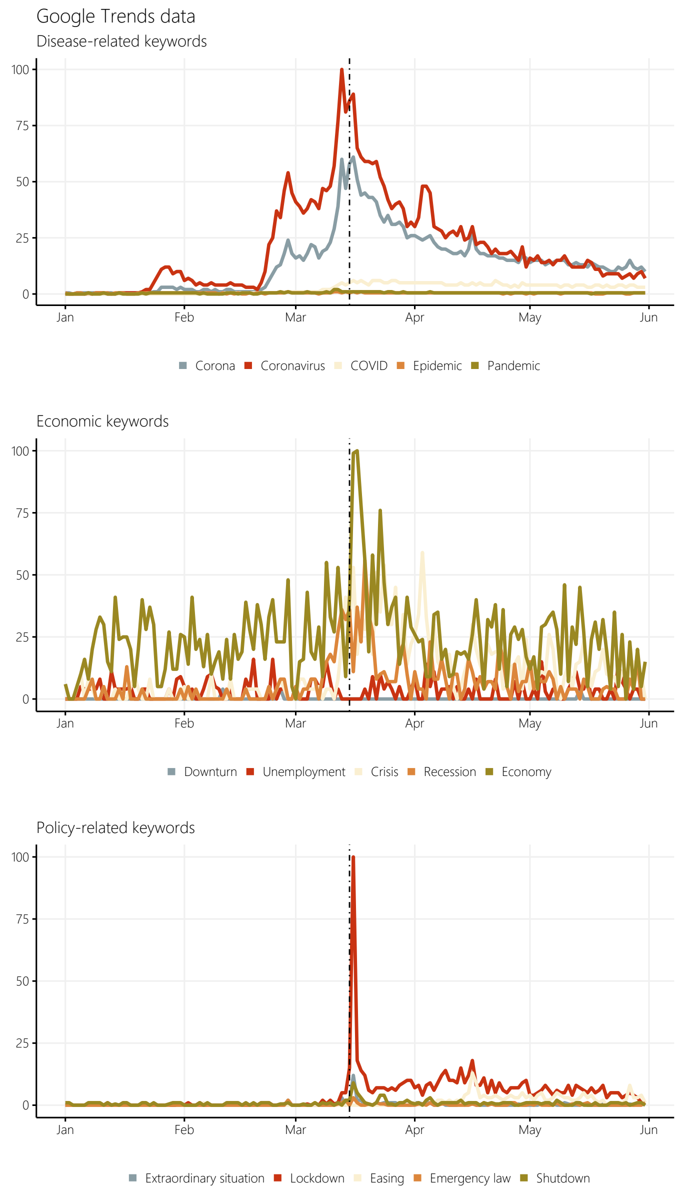

Figure 8: Daily Google Trends data for economic, policy- and disease-related search terms in Switzerland between 1 January and 31 May 2020. The values indicate the search interest relative to the highest point in the diagram for the selected region in the specified period. The value 100 represents the highest popularity of the search terms. A value of 50 means that the term is half as popular and a value of 0 means that not enough data was available for this term. I used German search terms, which are for the disease-related keywords: Corona, Coronavirus, COVID, Epidemie, Pandemie; for the economic keywords: Abschwung, Arbeitslosigkeit, Krise, Rezession, Wirtschaft; and for the policy-related keywords: Ausserordentliche Lage, Lockdown, Lockerung, Notrecht, Shutdown. The vertical dotted line marks the declaration of the "extraordinary situation" by the Swiss Federal Council on 16 March 2020.

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responded before the pandemic.

The dependent variable in this model, $\Delta I_{i,t}$, is the log nominal change in the investment plans of firm i for year t between the autumn survey in $t-1$ and the spring survey in t, as defined in Equation (1). Since the logarithm of zero is undefined, 12.7% of all firms are discarded because they have zero investment. Conditioning the sample to firms with positive investment does not induce a selection bias in the analysis, as shown in Section 6.

COVID_i is a binary, time-invariant dummy variable equal to 1 for all firms which completed the spring survey in 2020 after 16 March, and 0 otherwise, see Equation (4). This variable captures the difference between the treatment group that reported their investment plans in spring 2020 after the COVID shock and the control group. T_t is an indicator for the reference year of investment plan revisions. It is equal to 1 in 2020, indicating changes in investment plans for 2020, and 0 otherwise.

The main coefficient of interest is the interaction of these two dummy variables, i.e., the coefficient α_3 of the difference-in-differences term $T_t \cdot \text{COVID}_i$, which captures the effect of the COVID shock on firms' investment plans for 2020. It shows the extent to which firms during the pandemic changed their investment plans for the current year differently than the rest of the firms.

The model contains a large set of fixed effects that control for a variety of unobserved factors. First, it includes industry fixed effects, γ_j, built on the NACE Rev. 2 division level. These fixed effects absorb all factors that affect all firms i within the same industry j equally. Second, it contains region fixed effects, δ_k, built on seven NUTS-II regions. These fixed effects absorb all time-invariant differences between the regions k. The vector $\mathbf{X_{i,t}}$ controls for further firm characteristics, including expected current year investments ($I_{i,t,s=\text{spring } t}$) and the number of employees. Finally, $\varepsilon_{i,t}$ is the error term.

The DD model reveals the causal effect of the COVID-19 pandemic under the identifying assumption that firms' investment revisions would have displayed common trends absent the COVID shock. Although this assumption is not testable, examining whether companies revised their investment plans similarly in the pre-COVID period can help assess its plausibility. Further, I examine whether the firms in the treatment and control groups differ structurally from each other. This is of particular interest because the identification strategy relies on a time-dependent criterion. Depending on firms' response time in spring 2020, it divides the sample into early ("control group") and late responders ("treatment group").[22] Hence, if early and late responders differ systematically, the DD model runs the risk of not only identifying the COVID effect on firms' investment revisions but mixing it with the differences between early and late responders.

Table 2 provides a detailed breakdown of the sample into treatment and control groups by firm characteristics and the main variables used in the analysis. The treatment group consists of 649 firms, the control group of 551.

Regarding investment revisions, they do not differ significantly between treatment and control groups in the pre-COVID era (2014–2019). They are close to zero, on average. This holds for investment in GFCF as well as the three investment categories. Firms revised their investment plans similarly before the pandemic, which lends credibility to the identifying common trends assumption. Conversely, the groups differ significantly in how they have revised their investment plans for 2020. Treated firms have reduced their 2020 investment plans by about 15% on average, while all other firms' revisions were slightly positive. This suggests that these differences in investment revisions are rooted in the grouping criterion – the COVID-19 pandemic.

Regarding firm characteristics, firms in the treatment and control groups do not seem to differ structurally from each other. Treated firms are of similar size as firms in the control group (381 versus 344 FTE

[22] In fact, firms in the control group have consistently completed past investment surveys earlier than firms in the treatment group, by about one week on average.

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Table 2: Group-specific firm characteristics

Variables	Control group (2014–2019)	Treatment group (2014–2019)		Control group (2020)	Treatment group (2020)	
Firm size						
Small	0.42	0.40		0.44	0.46	
Medium	0.33	0.33		0.31	0.31	
Large	0.24	0.27		0.25	0.23	
Number of FTE	343.62	380.54		314.40	300.34	
Region						
Zurich	0.21	0.21		0.21	0.19	
Schweizer Mittelland	0.18	0.17		0.18	0.17	
Lake Geneva Region	0.08	0.13	***	0.09	0.14	***
Eastern Switzerland	0.22	0.17	***	0.20	0.17	
Ticino	0.06	0.09	***	0.06	0.09	**
North-West Switzerland	0.13	0.11	*	0.14	0.12	
Central Switzerland	0.12	0.12		0.12	0.12	
Export orientation						
Exporter	1.29	1.34	**	1.27	1.30	
Sector						
Manufacturing	0.34	0.33		0.32	0.31	
Construction	0.07	0.05	*	0.08	0.05	*
Service	0.56	0.58		0.58	0.59	
Investments $I_{i,t}$ (log)						
GFCF	13.20	13.54	**	13.16	13.15	
Equipment	12.72	13.00	*	12.68	12.58	
Construction	13.23	13.39		13.12	13.25	
R&D	11.78	11.99		11.81	12.15	
Investment revisions $\Delta I_{i,t}$						
GFCF	0.04	0.03		0.06	-0.14	***
Equipment	0.00	-0.01		0.03	-0.15	***
Construction	0.01	-0.00		-0.05	-0.02	
R&D	-0.01	-0.02		0.03	-0.01	
$\text{Uncertain}_{i,t}$ (1 if very/fairly uncertain)	0.10	0.12		0.12	0.30	***
$\text{Irreversible}_{i,t}$	0.37	0.34		0.38	0.33	
Observations	1852	1996		551	649	

This table provides a detailed breakdown of the sample into treatment and control groups by firm characteristics (size, location, export orientation, and industry) and the main variables used in the analysis. It distinguishes between treatment and control groups for 2020 and the time before. Unless otherwise stated, numbers are relative frequencies. The stars indicate if the means are significantly different at conventional level (***p < 0.01, **p < 0.05, *p < 0.1). The underlying p-values result from comparing treatment and control groups before and in 2020 with a two-sample t-test assuming unequal variance.

employees). About 40% are small firms (employing fewer than 50 employees), about a third are medium-sized firms, and about a quarter are large firms (employing more than 250 employees). Treatment and control groups both reported investment plans of similar reversibility, and they were equally certain about their realization. Only in 2020, the uncertainty of treated firms has surged.

Beyond, firms from the construction sector are slightly under-represented in the treatment group. This, however, holds true both in the pre-COVID period and in 2020. The same goes for regional differences in response behavior. Firms from the Lake Geneva region and Ticino, in particular, appear more frequently among late responders than companies based in German-speaking cantons.

Overall, these observations suggest that early and late responders do not differ systematically so that the DD model identifies the COVID effect properly. In the following result sections, I will examine these COVID-induced effects on firms' investment decisions in detail.

5 Results

This section presents my main empirical results. A natural starting point is the descriptive evidence from the survey, in which firms qualitatively report the expected change in their investment plans for 2020. Then, I turn to a more formal analysis of the pandemic's effects on investment decisions using the DD model outlined in the previous section.

5.1 Descriptive evidence

In this first descriptive approach, I examine how firms expected their investment plans to change in 2020 compared to 2019 and how these expectations changed between the two surveys in autumn 2019 and spring 2020. In both surveys, we asked firms to assess their expected change in investment qualitatively.[23] Firms could answer a 3-item Likert-scale and report that they expected their investments to increase, remain unchanged (or remain at zero), or decrease. As the survey in autumn 2019 was conducted 3–6 months before the declaration of the "extraordinary situation," it is unaffected by the COVID shock. I focus on the sample of firms for which I observe expected investment changes for 2020 in both surveys and present firms' answers in Figure 9 through Sankey diagrams. A Sankey diagram allows us to study flows. On either side of the diagram, the three answer choices are represented as vertical bars, the height of which conveys the share of firms that have opted for each answer choice. The flows between them are represented by arrows whose width is proportional to the number of firms that have changed their investment plans accordingly. I present Sankey diagrams separately for firms that in spring 2020 responded before ("control") and during the pandemic ("treatment").

Figure 9 provides evidence that during the pandemic, more firms expected their investments in 2020 to decrease relative to their expectations in late 2019. In autumn 2019, companies in both groups were spread similarly across the three answer choices (see bars on the left-hand side). About 30% each wanted to increase their investments in 2020, about half wanted to leave them unchanged, and about 20% wanted to reduce them. As is shown in the upper panel of Figure 9, the distribution remains similar in spring 2020 for firms responding before the pandemic, and the flows of responses between the two surveys are balanced. In fact, slightly more firms planned to increase (19.6%) than to decrease (16.4%) their

[23] We asked firms to assess their expected change in investment separately for investment in equipment and machinery, investment in construction, and investment in research and development. Since most firms invest in equipment and machinery, I focus on these results in what follows. The results for investment in construction and research and development are qualitatively the same and shown in Appendix C.1. They are qualitatively comparable to the results for investment in equipment and machinery.
The wording of the question is as follows: Relative to 2019, in the year 2020, our investment in Switzerland is likely to ☐ increase, ☐ remain unchanged (or remain at zero) or ☐ decrease.

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investments relative to their expectations in autumn 2019.

A completely different picture emerges after the COVID shock, as shown in the lower panel of Figure 9. During the pandemic, 27.2% of companies have revised their investment plans downwards compared to their plans in autumn. Only 16.7% have increased them. In total, 32.4% of the treatment group companies intend to reduce their investments in 2020 relative to 2019, 29.1% intend to increase them, and 38.5% intend to leave them unchanged.

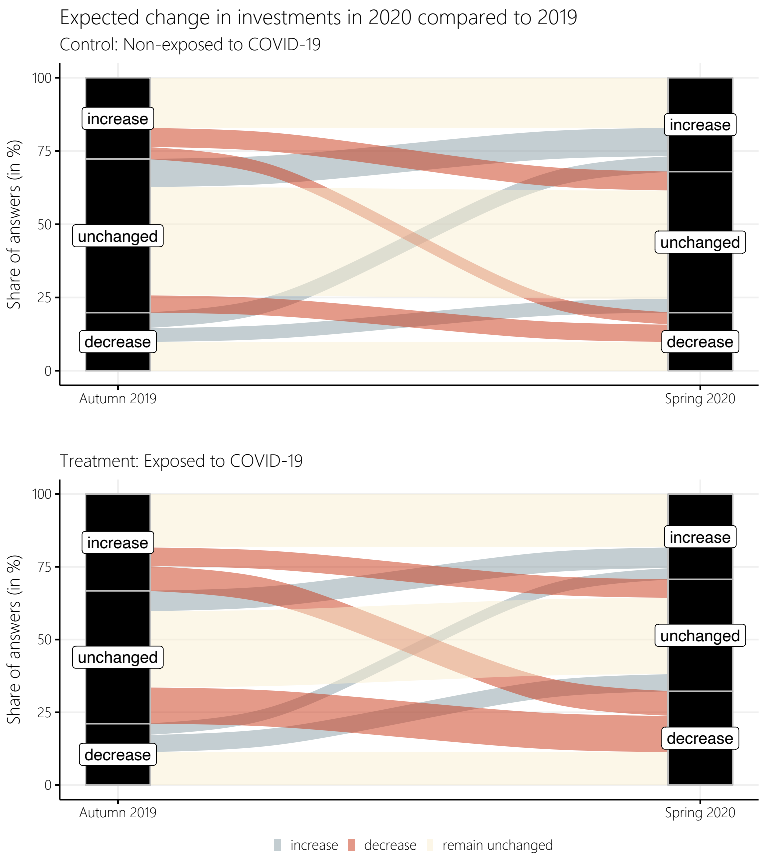

Figure 9: Sankey diagrams of firms' expected changes in investment in equipment and machinery in 2020 relative to 2019, as collected in the investment surveys in autumn 2019 and spring 2020. Flows are shown separately for firms in the control (upper panel) and treatment groups (lower panel).

5.2 The overall impact of the pandemic on firms' investment plans

The descriptive evidence presented in the previous section is suggestive, but by itself, it does not allow us to determine whether firms reduced their investment plans in 2020 due to the COVID shock. In this section, I use the empirical strategy presented in Section 4 to determine the causal effect of the pandemic on firms' investment plans and the extent to which firms have changed their expectations in response.

As a first step, I consider the evolution of firms' investment revisions that in spring 2020 were exposed to the pandemic in Figure 10. This series (labeled "treatment" in the figure) shows that the average revision between years was fairly stable at around 5% in the period before the pandemic from 2014 to

2019. After the pandemic hit, demarcated by a vertical line in the figure, revisions have fallen sharply into negative territory. Firms have reduced their investment plans for 2020 by more than 14%.

Naturally, firms could have revised their investment plans even in the absence of the pandemic. Any negative surprise between the two surveys in autumn 2019 and spring 2020 could have led firms to cancel or postpone their investments. The simplest way to control for such events is to plot the investment revisions of the group of firms that completed the survey in spring 2020, just before the pandemic. Hence, Figure 10 also shows how firms have revised their investment plans that were not yet exposed to the pandemic ("control").

Two lessons emerge from the use of this control. First, the control series follows the treatment series extremely closely in the pre-COVID period. The remarkable similarity and stability of the two series lend credibility to my identification strategy in verifying the parallel trend assumption. The two trends in the pre-COVID period are very similar, and in the absence of the pandemic, average investment revisions in 2020 would probably have been the same for both the treatment and control groups. Second, the control group series follows the pre-COVID trend also in 2020. It even increases slightly to 5.7%, while the treatment series is negative by more than twice as much.

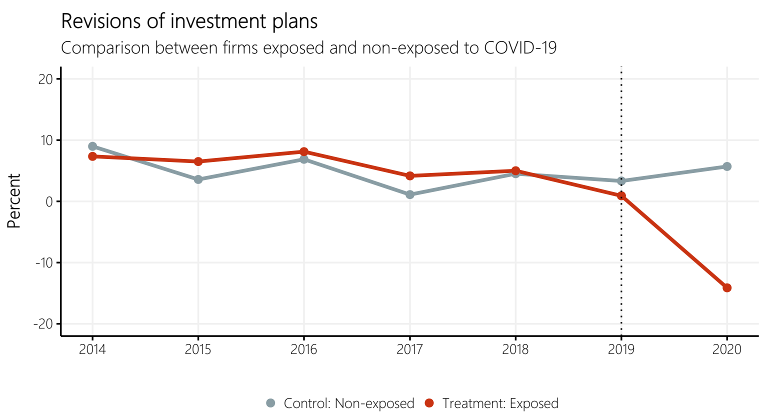

Figure 10: Effect of the COVID-19 pandemic on firms' investment plans: difference-in-differences evidence.
This figure compares the revision of firms' investment plans that in spring 2020 were exposed to the COVID-19 pandemic (treatment series) with those that were not exposed (control series) from 2013 to 2020. Exposure is defined by the response time in the survey wave of spring 2020: Companies that responded before 16 March belong to the control group. Companies that responded after 16 March belong to the treatment group. The vertical line in the year 2019 denotes the last year before the pandemic. Investment revisions for each year are defined as the percentage change between the investment amounts expected in the previous autumn and those expected in the current spring.

Table 3 summarises the visual evidence described above by presenting estimates of the difference-in-differences model specified in Section 4.2. Here and throughout the paper, standard errors are clustered on the level of the individual firm. Control variables are included, but coefficients are not reported. The four columns consider (i) total investments (gross fixed capital formation, GFCF) and three subcategories thereof: (ii) investment in equipment and machinery, (iii) investment in construction, and (iv) investment in research and development (R&D).

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Table 3: DD estimates of the effect of the COVID-19 shock on investment revisions

	Investment revisions ($\Delta I_{i,t}$)			
	GFCF	Equipment	Construction	R&D
	(1)	(2)	(3)	(4)
T_t	−0.017	0.018	−0.049	0.077
	(0.041)	(0.034)	(0.064)	(0.062)
COVID$_i$	−0.023	0.002	0.0003	−0.026
	(0.029)	(0.023)	(0.038)	(0.043)
$T_t \times$ COVID$_i$	−0.136**	−0.171***	0.046	−0.070
	(0.055)	(0.052)	(0.081)	(0.084)
Industry fixed effects	Yes	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes	Yes
Observations	3,664	3,318	1,788	963
R^2	0.033	0.033	0.039	0.091
Adjusted R^2	0.010	0.008	-0.004	0.021
Residual Std. Error	0.726 (df = 3579)	0.589 (df = 3233)	0.665 (df = 1711)	0.554 (df = 893)
F Statistic	1.446*** (df = 84; 3579)	1.327** (df = 84; 3233)	0.904 (df = 76; 1711)	1.300* (df = 69; 893)

Note: *p<0.1; **p<0.05; ***p<0.01
Control variables are included but coefficients not reported.
Cluster-robust standard errors in parenthesis.

Column (1) in Table 3 is the estimation counterpart of Figure 10. It shows that revisions are large and precisely estimated. In response to the COVID-19 pandemic, firms have reduced their total investment plans for 2020 by 14 percentage points.

This result is essentially driven by investments in equipment, for which I find a significant and strongly negative coefficient in Column (2). Treated firms reduce their investment plans by 17 percentage points compared to other firms. I consider the magnitude of this effect substantial and economically relevant. Meanwhile, I find no significant effects on investments in construction (Column 3) or research and development (Column 4). While the difference-in-differences interaction term is slightly positive for the former, it is slightly negative for the latter. Both models, however, are not precisely estimated. In what follows, I will, therefore, focus on the impact of the pandemic on investment decisions for equipment and machinery.

To gain insight into which investment projects were abandoned due to the COVID shock, I examine how the pandemic influenced firms' motives to invest. The investment survey asks firms whether their investments serve one or more of the following purposes: replacement, the extension of the production capacity, streamlining production, or fulfilling environmental protection and regulations by trade law. With this information, I construct an indicator that equals one if a firm allocates its investment to a purpose it did not intend in the previous survey and zero otherwise. Using logistic regressions, I am thus able to examine the probability of planning specific investment projects due to the pandemic.[24]

Table 4 shows the logit coefficients in log-odds form. Column (1) demonstrates that the odds of launching investments in response to the pandemic are estimated to be highest and not different from zero for replacement. Hence, the pandemic does not seem to influence whether companies make replacements. This is not surprising because replacement investments are essential and more or less inevitable. Replacements may be required to replace worn-out or failing equipment. They arise from the continuous depreciation of fixed capital assets and are necessary to ensure a smooth production process and maintain operations. Moreover, they are relatively risk-free compared to the other purposes because they do not change the size of the enterprise and do not increase the capital commitment.

This is different from investments for extensions. They have the effect of increasing both capital and ca-

[24] Alternatively, the indicator could also reflect the abandonment of certain investment motives. However, the regression results with this variant do not turn out significant, see Table 15 in the appendix. I interpret these differences in such a way that companies do not entirely abandon intended investment purposes but reduce them in scope. If planned earlier, motives were not completely abandoned during the crisis. If not planned earlier, certain motives were not additionally pursued.

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Table 4: DD estimates of the effect of the COVID-19 shock on investment motives

	Purpose of launched investments			
	Replacement	Extension	Streamlining	Environment
	logistic	*logistic*	*logistic*	*logistic*
	(1)	(2)	(3)	(4)
T_t	-1.114^{***}	-0.467^{**}	-0.252	0.016
	(0.206)	(0.187)	(0.185)	(0.242)
COVID_i	0.268^{***}	0.215^{*}	0.376^{***}	0.247
	(0.102)	(0.123)	(0.129)	(0.170)
$T_t \times \text{COVID}_i$	0.079	-0.504^{**}	-0.228	-0.267
	(0.267)	(0.248)	(0.254)	(0.310)
Industry fixed effects	Yes	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes	Yes
Observations	3,837	2,153	2,474	1,647
Log Likelihood	-2,007.363	-1,294.146	-1,321.133	-938.672
Akaike Inf. Crit.	4,186.727	2,754.293	2,806.266	2,045.345

Note: *p<0.1; **p<0.05; ***p<0.01
Control variables are included but coefficients not reported.
Cluster-robust standard errors in parenthesis.

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pacity, which changes revenues and total costs of the firm. Therefore, a company will invest in expanding its facilities only if it has a positive outlook for the future. For example, if it expects growth, resulting in favorable sales and profit expectations, or if the interest rate level for external financing is rising. Such prospects were not given for most of the firms under the pandemic, as confirms Column (2). The COVID shock has decreased the odds of investing in expansions significantly by 39.6%. Alternatively, the odds for expansions are only three-fifth compared to the odds before the crisis.

Similarly, the odds of investing for streamlining (Column 3) or environmental protection (Column 4) have decreased with the pandemic. Both point estimates are negative but not significant.

5.3 The heterogeneous responses across firms

Having documented the pandemic's impact on aggregate investment plans in the previous section, we are now in a position to address whether revisions to investment plans differed across firms. Likely, the pandemic did not affect all firms equally. For one, because firms inherently differ on a range of multiple firm characteristics. For another, because firms were affected very differently by both the geographic and the sectoral components of the shock generated by the COVID-19 pandemic and the measures taken to contain it. I begin this section by first examining investment revisions differentiated by firm characteristics and then turn to two pivotal metrics governing the COVID-19 crisis: exposure to the virus and sensitivity to government-imposed lockdown measures.

Investment revisions by firm characteristics

To find out which companies have revised their investment plans more than others, I decompose the results of the previous section by firm characteristics in this part of the analysis. In particular, I divide firms into groups according to different firm characteristics (sector, size, age, and export orientation) and re-estimate Equation 5 to see how the average treatment effects differ across these groups. Figure 11 presents the resulting conditional treatment effects.[25]

[25] The corresponding regression tables are given in Appendix C.3.

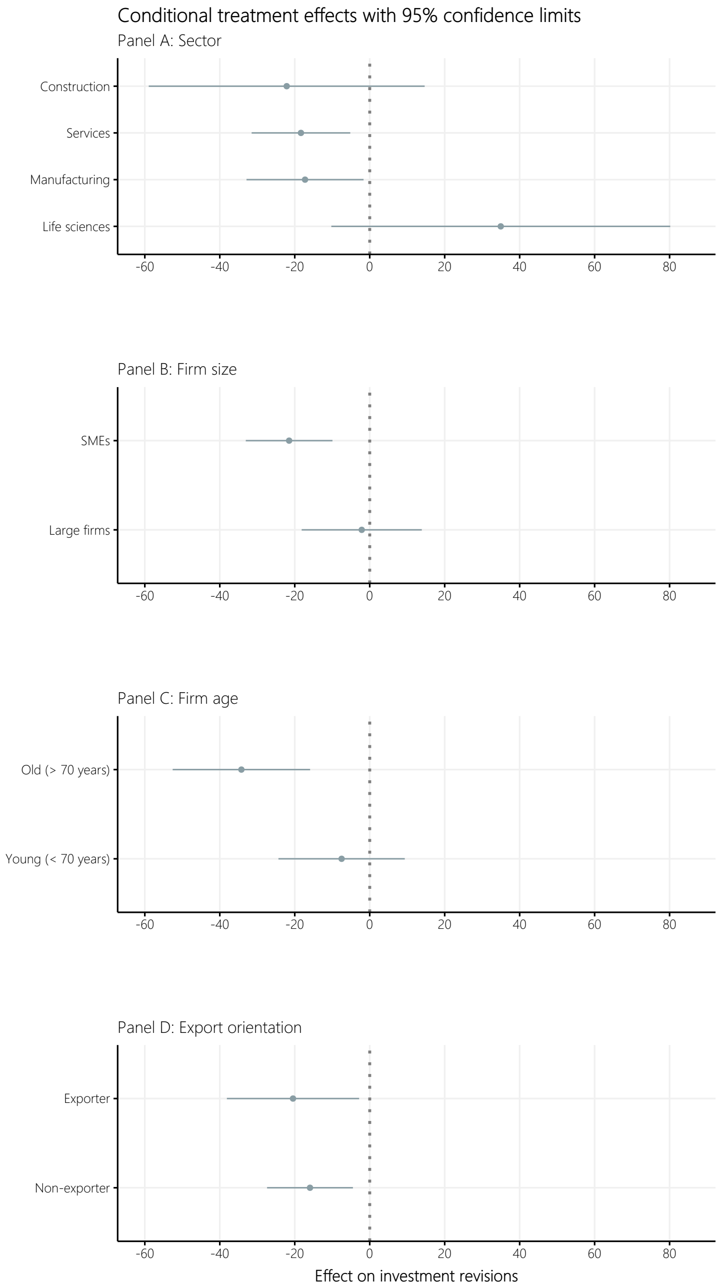

Figure 11: Conditional treatment effects of the COVID-19 pandemic on firms' investment plans: difference-in-differences evidence. The figure shows regression results by sectors (Panel A), firm size (Panel B), firm age (Panel C), and export orientation (Panel D).

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Panel A shows the regression results by sectors.[26] This top panel of Figure 11 clarifies that the contraction of planned investments is most pronounced in the construction sector. Although imprecisely estimated, construction companies have revised their plans on average by roughly −22 percentage points. Revisions are similarly negative and significantly estimated in the services and manufacturing sectors. Service providers (−18.3 percentage points) reduced their investment plans slightly more strongly than manufacturing firms (−17.3). By contrast, firms operating in other industries, for instance, in the life sciences, have, on average, increased their investments following the COVID shock. Figure C.3 in the appendix shows the sectoral decomposition per industry (NACE Rev. 2 divisions) in greater detail.

Panel B in Figure 11 shows that small and medium-sized enterprises (SMEs, defined as firms with less than 250 employees) have reduced their investment plans significantly as a result of the crisis. Their average investment revision is −21.5 percentage points. On average, they reduced their plans by more than larger firms. The average revision of large firms (−2.1) is not significantly different from zero.

A similar contrast emerges between companies that have been around for several generations and younger firms, as shown by Panel C. Companies older than 70 years have sharply cut their investment plans (−34.2). Younger firms have responded less strongly (−7.5).

Finally, Panel D reveals that the COVID shock has caused both exporting and non-exporting firms to reduce their investment plans significantly. The negative revision of investment plans is larger in the case of exporting (−20.5) than for non-exporting (−15.9) firms.

Regional variation and exposure to the virus

I continue by examining the geographic component of the shock generated by the COVID-19 pandemic. A key metric of the COVID-19 crisis is the spread of and exposure to the virus. In Switzerland, the virus has spread very differently from region to region, as shown in Figure 3 earlier. This regional heterogeneity in the intensity of the pandemic may translate into heterogeneous responses of the companies depending on whether they are located in areas of high or low viral intensity. For example, a locally higher virus incidence may prompt households to become more cautious, in turn affecting nearby firms negatively (e.g., fewer visits to shops or restaurants). In the same vein, firms in regions with higher virus intensity may be inclined to take stronger operational measures to manage the economic consequences of the pandemic than firms in regions with lower virus intensity. Therefore, investment revisions may be related to the regional differences in the spread of the virus, reflecting the local severity of the pandemic. Investment revisions could thus – in a figurative sense – be seen as firms' infections with the virus itself.

To disentangle the average treatment effect of the COVID shock on firms' investment plans from the regional variation in the spread of the virus, I start with estimating conditional treatment effects by regions[27] and plot the estimation results in Figure 12. Comparing firms' investment revisions in Figure 12 with the regional COVID case counts in Figure 3 reveals striking correspondences. Firms in Ticino (−52.7), North-West Switzerland (−57.2), and Lake Geneva Region (−21.4) have revised their 2020 investment plans the most. Conversely, companies in Eastern (−3.4) and Central (−3.0) Switzerland did not revise their investment plans significantly from zero.

[26]Sector definitions are based on the following industry codes (NACE, Rev. 2). Manufacturing: NACE 10-33. Construction: 41-43. Services: 45-96. Life sciences is a subgroup of the manufacturing sector and consist of pharmaceuticals (21), biotech research (7211), agrochemicals (202), and electrical and mechanical medical technology (2660, 325).

[27]The corresponding regression table is given in Appendix C.3.

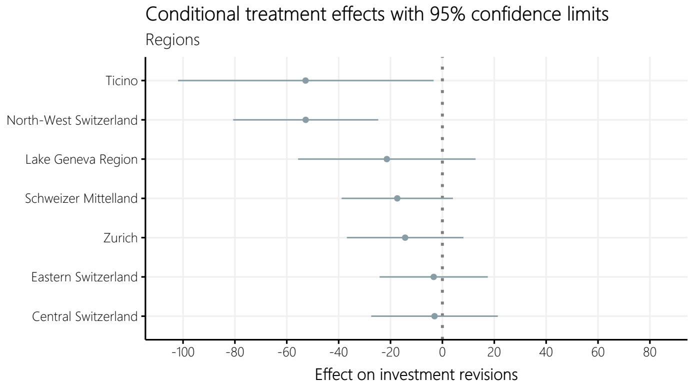

Figure 12: Conditional treatment effects of the COVID-19 pandemic on firms' investment plans: difference-in-differences evidence. The figure shows regression results by regions.

Indeed, local virus intensity drives investment revisions. Table 5 shows difference-in-differences regression results, including regional virus intensity measured by COVID cases and COVID deaths (both in percent of the cantonal population). Investment revisions significantly decrease in both virus cases (see Column 1) and fatalities (see Column 2). A one percent increase in cantonal viral incidence decreases investment plans by more than 25 percentage points. The effect of a comparable increase in COVID fatalities is more than a factor of 10 greater.

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Table 5: DD estimates of the effect of the COVID-19 shock on investment revisions

	Dependent variable:	
	Revisions in investment in equipment ($\Delta I_{i,t}$)	
	(1)	(2)
T_t	−0.067*	−0.037
	(0.037)	(0.030)
COVID_i	−0.009	−0.017
	(0.053)	(0.042)
COVID cases	−0.258***	
	(0.082)	
COVID deaths		−2.896***
		(0.923)
$T_t \times \text{COVID}_i$	−0.067	−0.095
	(0.081)	(0.064)
$T_t \times \text{COVID}_i \times$ COVID cases	−0.327	
	(0.216)	
$T_t \times \text{COVID}_i \times$ COVID deaths		−4.144*
		(2.292)
Constant	0.121**	0.093*
	(0.052)	(0.049)
Industry fixed effects	Yes	Yes
Region fixed effects	Yes	Yes
Observations	3,312	3,312
R^2	0.036	0.036
Adjusted R^2	0.011	0.011
Residual Std. Error (df = 3229)	0.588	0.588
F Statistic (df = 82; 3229)	1.458***	1.458***

Note: *p<0.1; **p<0.05; ***p<0.01
Control variables are included but coefficients not reported.
Cluster-robust standard errors in parenthesis.

Sensitivity to lockdown and government-imposed restrictions

I now turn to the sectoral component of the shock generated by the government response to the COVID-19 pandemic. Another possible reason for variation in investment revisions across firms is that some of the firms were more constrained by the lockdown measures imposed by the government than others. Firms' sensitivity to the lockdown measures may depend on the extent to which lockdown policies prohibited or limited certain business activities (e.g., restaurants or leisure facilities), the inherent dependence of the occupation on physical proximity to other people, or the general ability of a firm's workers to do their work from home.

To investigate this hypothesis, I assess how firms' investment revisions depend on their exposure to the government-imposed lockdown restrictions. I measure firms' sensitivity to these restrictions using the lockdown index and the home office index described in Section 3. Table 6 reports the corresponding regression results. In these estimations, I interact the difference-in-differences term from Equation 5 with the lockdown restrictions variables, extending the baseline difference-in-differences model into a difference-in-differences-in-differences (DDD) framework. This adds another layer of heterogeneity to the estimation and quantifies the difference in the COVID-induced effect between firms facing lesser and greater restrictions.

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Table 6: DDD estimates of the effect of the COVID-19 shock on investment revisions

	Dependent variable:	
	Revisions in investment in equipment ($\Delta I_{i,t}$)	
	(1)	(2)
$T_t \times \text{COVID}_i$	0.029	-0.449^{***}
	(0.112)	(0.126)
$T_t \times \text{COVID}_i \times$ Lockdown index	-0.636^{**}	
	(0.301)	
$T_t \times \text{COVID}_i \times$ Home office index		0.613^{**}
		(0.284)
Industry fixed effects	No	No
Region fixed effects	Yes	Yes
Observations	3,317	3,068
R^2	0.014	0.018
Adjusted R^2	0.010	0.013
Residual Std. Error	0.588 (df = 3301)	0.594 (df = 3052)
F Statistic	3.235^{***} (df = 15; 3301)	3.649^{***} (df = 15; 3052)

Note: *p<0.1; **p<0.05; ***p<0.01
Control variables are included but coefficients not reported.
Cluster-robust standard errors in parenthesis.

I find strong evidence that firms' investment revisions depend on their exposure to the government-imposed lockdown restrictions. The lockdown restriction variables, namely, the lockdown and the home office index, are both statistically significant and have the expected (opposite) signs.

Column (1) in Table 6 shows that firms' investment revisions decrease with the lockdown index: a firm whose production requires relatively more physical proximity decreases its investment plans more strongly than firms whose production requires less physical proximity. Occupations that do not require much physical proximity include, for example, chemical engineers, farmers, or office and hotel cleaners. Conversely, Column (2) in Table 6 shows that revisions increase with the home office index. Firms whose employees can easily perform their tasks remotely decreased their 2020 investment plans significantly less than firms who can easily operate from home. Occupations that can easily operate from home include, for example, software developers, economists, or lawyers.

While my results so far document that the COVID shock has on average depressed investment projects, the positive relationship between the home office index and investment revisions give us an idea of which firms did revise their investment plans significantly less and which (few) firms were actually able to increase their 2020 investment plans in response the COVID-19 crisis. These could be firms whose human capital accounts for a large share in their production or service provision, that employ many well-trained employees, and that have – already before the crisis – digitized both internal and external processes to a high degree. I group these firms under the term "innovative firms." Innovative firms may have been more agile and found it easier to adapt to the rapidly evolving conditions during the lockdown in spring 2020. Similarly, innovative firms may have had it easier to adopt digital processes (e.g., teleworking, digital procurement, or distribution) and thus been more independent from the government-imposed lockdown measures.

To test this hypothesis, I examine how firms' investment revisions depend on various innovation features. Table 7 reports the corresponding regression results. In these estimations, I interact the difference-in-differences term from Equation 5 with the indicators for innovation. This information comes from the KOF Innovation Survey 2018 and is matched at the firm level. Specifically, I use an indicator for (i) the

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education level of employees[28], (ii) personnel expenses[29], (iii) the use of information and communication technologies (ICT)[30], and (iv) the relevance of e-commerce[31].

Table 7: DDD estimates of the effect of the COVID-19 shock on investment revisions

	Dependent variable:			
	Revisions in investment in equipment ($\Delta I_{i,t}$)			
	High education level	High personnel cost share	High ICT use	E-Commerce
	(1)	(2)	(3)	(4)
$T_t \times \text{COVID}_i$	−0.208***	−0.216***	−0.347***	−0.331***
	(0.072)	(0.079)	(0.095)	(0.100)
$T_t \times \text{COVID}_i \times$ Education	0.920***			
	(0.217)			
$T_t \times \text{COVID}_i \times$ Personnel cost		0.281*		
		(0.150)		
$T_t \times \text{COVID}_i \times$ ICT			0.396**	
			(0.194)	
$T_t \times \text{COVID}_i \times$ E-Commerce				0.576**
				(0.265)
Industry fixed effects	Yes	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes	Yes
Observations	2,055	2,034	1,477	1,006
R^2	0.040	0.035	0.051	0.069
Adjusted R^2	0.005	-0.0001	0.006	0.009
Residual Std. Error	0.584 (df = 1982)	0.575 (df = 1961)	0.559 (df = 1409)	0.538 (df = 944)
F Statistic	1.155 (df = 72; 1982)	0.999 (df = 72; 1961)	1.135 (df = 67; 1409)	1.147 (df = 61; 944)

Note: *p<0.1; **p<0.05; ***p<0.01
Control variables are included but coefficients not reported.
Cluster-robust standard errors in parenthesis.

The results in Table 7 suggest that the investment plans of more innovative firms were indeed more resilient to the COVID shock than those of less innovative companies. Firms that employ many well-educated employees reduced their investment plans by 92.0 percentage points less than firms with fewer qualified employees (Column 1). Comparably, firms with high personnel costs revised their investment plans by 28.1 percentage points less (Column 2). Companies with a high education level of their employees and high personnel expenditure are likely to be less bound to a specific location, which means that the majority of these companies were able to carry out their activities even during the lockdown and were thus less restricted by the pandemic and the policy measures. A corporate culture in which the use of information and communication technologies was already common practice before the pandemic (Column 3) further favors this hypothesis. Companies whose employees did not or could not use ICT in their day-to-day business cut their investments by 39.6 percentage points more. Besides, companies that were already using the internet as both a procurement and sales channel before the crisis (Column 4) revised their investment plans for the current year by significantly less. Companies without corresponding channels reduced their plans to invest by more than 50 percentage points more.

5.4 The factors driving investment revisions

Having documented in the previous sections the impact of the pandemic on investment plans in the aggregate and the heterogeneous investment revisions across firms, we now turn to the question of what factors drove these revisions. In this section, I will examine the role of several determinants of

[28] The education level of employees is high if, by the company's own account, the share of graduates (university or *Fachhochschule*) in total employment exceeded 50% at the end of 2018, and low otherwise.

[29] The personnel cost share is high if, by the company's own account, the share of personnel costs in turnover exceeded 50% in 2018, and low otherwise.

[30] The use of ICT is high if, by the company's own account, the share of employees who use a computer (e.g., PC, workstation, terminal, laptop), the internet, the intranet, and mobile broadband (3G, 4G) in their work averaged between 61-100% in 2018, and low otherwise.

[31] E-commerce is relevant if, by the company's own account, the firm made purchases and/or sales via the internet and the respective share of purchases/sales of goods and services exceeded 50% of total purchases/sales in 2018, and irrelevant otherwise.

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investments. These include uncertainty, demand, financial resources, and technological factors. The advantage of the data I use for this is that they are collected with the investment survey, making them firm-specific and time-varying. Moreover, since they were collected before the crisis already, they are also exogenous.

Uncertainty, irreversible investments, and real options theory

The outbreak of COVID-19 and the ensuing global pandemic has led to a massive surge in uncertainty. Figure 13 shows how three selected measures of uncertainty evolved in Switzerland over the past twenty years. These measures include a newspaper-based measure, subjective uncertainty in business expectation surveys, and stock market volatility, all figuring prominently in the long literature on economic uncertainty (see Bloom, 2014; Baker et al., 2020). They confirm an enormous increase in uncertainty coinciding with the COVID-19 pandemic in spring 2020.[32] Measured by the news and survey-based indicators, the uncertainty shock is larger than the one associated with the Great Recession of 2008-09 and unprecedented to date.

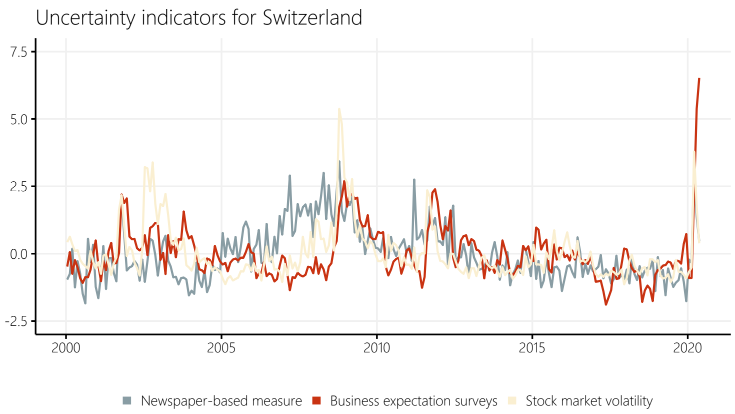

Figure 13: This figure shows three selected measures of uncertainty for Switzerland from 2000 to 2020. The newspaper-based measure represents a part of the economic policy uncertainty indicator developed by Baker et al. (2016). It counts Swiss newspaper articles that contain words related to "uncertainty." It is based on newspaper articles from "Blick," "Neue Zürcher Zeitung," and "Tages-Anzeiger". The measure of subjective uncertainty in business expectation surveys is based on the KOF business tendency surveys. It depicts disconformity in firms' expectations constructed along the lines proposed by Theil (1952). Stock market volatility is based on the Volatility Index on the Swiss Market Index (VSMI). All indicators are standardized to mean one and unit variance.

The idea that investment decisions are sensitive to investors' perceived uncertainty is not new. Many economic decisions involve an intertemporal element in that the moment of decision-making and its realization are separated in time. Because the future is unknown, companies face uncertainty when making decisions. In the presence of uncertainty, they resort to expectations to inform their decisions and guide their actions. This holds in particular for investment decisions, which are often costly, long-term, and irreversible.

While there is always uncertainty about the future, a sharp increase in uncertainty – such as during the COVID-19 pandemic – is thought to impair firms' ability to form reliable expectations. A veil of

[32]Significant uncertainties surrounded non-economic, economic, and policy aspects of the pandemic alike, for instance: the infectiousness and lethality of the virus; the time needed to develop and deploy effective vaccines; the duration and effectiveness of containment strategies and their immediate impact on economic activity; the design of policies in the event of further waves of the pandemic; the policy decisions on which sectors and workers receive government support; the speed of normalization once containment measures are relaxed; and the long-term impacts of the pandemic on productivity and growth, to name a few.

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uncertainty blocks their view of the future, making it harder to make forward-looking decisions.

The economic theory highlights different channels through which uncertainty affects investment decisions. One of the most prominent channels revolves around "real options." Real options theory (Bernanke, 1983; Pindyck, 1988; Caballero, 1991) describes firms' investment choices as a series of options. If uncertainty increases, firms resort to wait-and-see behavior until more information becomes available to inform their decision. Until then, firms postpone their investment plans. Put differently, when uncertainty is high, the option value of delaying investments is high. Real options, however, are not universal. They require investment to be irreversible for uncertainty to affect investment. After all, reversible investment does not lead to the loss of an option.

Further theoretical channels that explain negative investment effects from uncertainty include borrowing constraints due to higher risk premia (Gilchrist et al., 2014; Christiano et al., 2014; Arellano et al., 2019) and a loss of confidence caused by ambiguity aversion (Hansen et al., 1999; Ilut and Schneider, 2014). By contrast, there are also theoretical channels that highlight positive investment effects from uncertainty. These include growth options (Bar-Ilan and Strange, 1996; Stein and Stone, 2013; Kraft et al., 2018) and the Oi-Hartman-Abel (Oi, 1961; Hartman, 1972; Abel, 1983) effect.

Overall, the evidence offered by economic theory on the relationship between uncertainty and investment is ambiguous. Therefore, its sign needs to be determined on empirical grounds. To investigate this relation formally during the COVID-19 pandemic, I present estimation results in Table 8. In these estimations, I use as measures of uncertainty and irreversibility firms' responses taken directly from the investment survey, which I have described in Section 3. As the survey questions on uncertainty and irreversibility were only introduced in spring 2015, estimations are based on a reduced sample of 2,977 firm-year observations.

Table 8: DD estimates of the effect of uncertainty on (irreversible) investments

	Dependent variable:		
	Revisions in investment in equipment ($\Delta I_{i,t}$)		
	(1)	(2)	(3)
$\text{Uncertain}_{i,t}$	−0.061***	−0.043**	−0.007
	(0.014)	(0.017)	(0.032)
$\text{Irreversible}_{i,t}$		−0.054	−0.072
		(0.037)	(0.065)
$T_t \times \text{COVID}_i$			−0.149*
			(0.085)
$\text{Uncertain}_{i,t} \times \text{Irreversible}_{i,t}$		−0.051*	−0.091*
		(0.028)	(0.048)
$T_t \times \text{COVID}_i \times \text{Uncertain}_{i,t} \times \text{Irreversible}_{i,t}$			−0.207*
			(0.117)
Industry fixed effects	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes
Observations	2,977	2,944	2,944
R^2	0.037	0.038	0.047
Adjusted R^2	0.010	0.010	0.015
Residual Std. Error	0.586 (df = 2894)	0.586 (df = 2859)	0.584 (df = 2847)
F Statistic	1.362** (df = 82; 2894)	1.363** (df = 84; 2859)	1.471*** (df = 96; 2847)

Note: *p<0.1; **p<0.05; ***p<0.01
Control variables are included but coefficients not reported.
Cluster-robust standard errors in parenthesis.

Column (1) in Table 8 shows that firms considering the realization certainty of their investment plans as "fairly uncertain" or "very uncertain" reduce them by six percentage points relative to firms that did not report any uncertainty. The effect is statistically significant at a 1% level.

When I test for the presence of real options and hence control for irreversibility in Column (2), I find a negative effect of uncertainty on the revision of irreversible investment plans. The coefficient of the interaction term between uncertainty and irreversibility is negative and statistically significant. More precisely, firms indicating uncertainty decrease irreversible investment by 5.1 percentage points more (or increase irreversible investment by 5.1 percentage points less) than firms that do not indicate uncertainty.

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This effect is in line with standard real options theory. The magnitude of the effect is substantial and economically relevant, even though it is slightly smaller than the one found in earlier studies using the same survey data. Dibiasi et al. (2018) show that policy uncertainty caused by an unexpected outcome of a popular vote in Switzerland decreased irreversible investments of Swiss firms by 13 percentage points. Binding and Dibiasi (2017) find that exchange rate uncertainty decreased irreversible investment by 9.8 percentage points in the same spirit.

However, given the unprecedented increase in uncertainty during the recent crisis, I expect to uncover larger real options effects when focusing on treated firms during the COVID-19 pandemic. Indeed, when I interact the real options terms ($\text{Uncertain}_{i,t} \cdot \text{Irreversible}_{i,t}$) with the difference-in-differences interaction term ($T_t \cdot \text{COVID}_i$) in Column (3) of Table 8, I find a strongly negative and significant effect during the pandemic. This effect suggests that the COVID-19 pandemic has caused firms being "fairly uncertain" or "very uncertain" about their investments to decrease their plans for irreversible investments by 20 percentage points more than firms that were certain about their irreversible investments. This result is consistent with real options theory, and its magnitude reflects the vast increase in uncertainty in the recent crisis. Shrouded in a veil of uncertainty during the lockdown, firms abandoned their investment plans which were not easily reversible to a large scale.

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Demand, financial resources, and technological factors

What further factors hinder firms' investments? Did firms reduce their investments in the pandemic because of negative demand trends or because they lack the financial resources to stem them? To examine this question, I exploit that the investment surveys in autumn also collect information on the factors influencing firms' investment plans for the next year. The factors considered include demand trends (such as capacity utilization and expected changes in sales or prices), financial resources (such as expected profits, availability and cost of credit, or return on investment), and technological development. Firms' answers range from a very limiting to a very stimulating influence of each of the factors.

Table 9 presents difference-in-differences-in-differences evidence on the effect of the pandemic on investments that were planned before the pandemic in anticipation of the respective influencing factors.

Table 9: DDD estimates of the effect of the COVID-19 shock on investments by influence factors

	Dependent variable:		
	Revisions in investment in equipment ($\Delta I_{i,t}$)		
	OLS		
	(1)	(2)	(3)
$T_t \times \text{COVID}_i$	−0.328***	−0.142**	−0.468***
	(0.086)	(0.062)	(0.133)
$T_t \times \text{COVID}_i \times$ Demand	0.094		
	(0.067)		
$T_t \times \text{COVID}_i \times$ Financial resources		−0.205**	
		(0.082)	
$T_t \times \text{COVID}_i \times$ Technological factors			0.299**
			(0.119)
Industry fixed effects	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes
Observations	1,830	2,192	1,629
R^2	0.058	0.048	0.063
Adjusted R^2	0.012	0.008	0.010
Residual Std. Error	0.592 (df = 1745)	0.587 (df = 2104)	0.578 (df = 1542)
F Statistic	1.268* (df = 84; 1745)	1.212* (df = 87; 2104)	1.198 (df = 86; 1542)

Note: *p<0.1; **p<0.05; ***p<0.01
Control variables are included but coefficients not reported.
Cluster-robust standard errors in parenthesis.

Column (1) shows no significant effect of the pandemic on investment projects driven by demand expectations. Firms that planned investments for 2020 because they expected a stimulating effect of demand

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did not change their investment plans in response to the pandemic any differently than firms whose investments for 2020 were not driven by demand. However, I find a negative effect in the case of financial resources (Column 2). Firms that planned their 2020 investments in anticipation of a stimulating financial situation reduced their investment plans significantly more than firms that did not make their 2020 investments dependent on a positive expected financial situation. The difference amounts to 21 percentage points. This suggests that the pandemic has discouraged firms from investing due to a deteriorated financial situation and profitability. This contrasts with the influence of technological development, as shown in Column (3). The pandemic has caused firms that expected their investments to be stimulated by technical factors to increase their 2020 investments even further. The magnitude of the estimated effect is substantial and amounts to 30 percentage points.

6 Placebo and main sensitivity checks

The difference-in-differences estimates rely on the assumption of a common trend absent the COVID-19 pandemic. To examine whether this assumption is plausible, I study whether the DD estimation identifies a spurious effect before COVID-19. To this end, I generalize the DD model to the following placebo DD model:

$$\Delta I_{i,t} = \gamma_i + \delta_{j,t} + \sum_{\substack{k=2015,\ldots,2020 \\ k\neq 2019}} \beta_{1k} T_k + \beta_2 \mathrm{COVID}_i + \sum_{\substack{k=2015,\ldots,2020 \\ k\neq 2019}} \beta_{3k} T_k \cdot \mathrm{COVID}_i + \varepsilon_{i,t} \quad (6)$$

The placebo model estimates the difference-in-differences interaction term, capturing the COVID effect for every period (but one) before and during the pandemic. It excludes one period to avoid perfect multicollinearity. I chose to omit the interaction term for 2019 from the regression, the last year before the pandemic. The model then estimates placebo treatment effects for each year relative to 2019. The estimated series of coefficients on the variable of interest, β_{3k}, is a placebo test for whether the treatment affected the outcome between the two groups. The coefficients are plotted together with their 90% confidence intervals in Figure 14. In contrast to Figure 10, which plots average investment revisions for the treatment and control groups and shows the unconditional outcome evolution over time, this figure depicts a *conditional* outcome distribution.

Figure 14 illustrates the pandemic's substantial negative effect identified by the DD model in the period between 2019 and 2020. Plans to invest in equipment and machinery are substantially revised downwards. On the other hand, we do not observe a significant effect of the pandemic in the years leading up to it. This supports the validity of the central identifying assumption that the groups of firms would have displayed a common trend in the outcome absent the pandemic.

Apart from these placebo checks, I conduct various sensitivity and robustness checks, of which only the most important ones are shortly discussed here.

First, I show that the results do not depend on my choice of the treatment date, which classifies survey respondents in spring 2020 into treatment and control groups. Table 10 provides robustness checks of the baseline DD estimation (Table 3) by altering the treatment date. In particular, I choose 28 February (declaration of the "special situation"), 1 March, and 5 March (first COVID-related death in Switzerland) as alternative treatment dates. In a further specification, I exclude all firms participating in the survey between 1 March and 16 March and assign the respondents after 16 March to the treatment group. This specification aims to make the estimation independent of any specific choice of the treatment date.

In the alternative specifications, the main results remain significant and qualitatively unchanged. In response to the pandemic, firms reduce their investment plans by 9 to 14 percentage points. This shows

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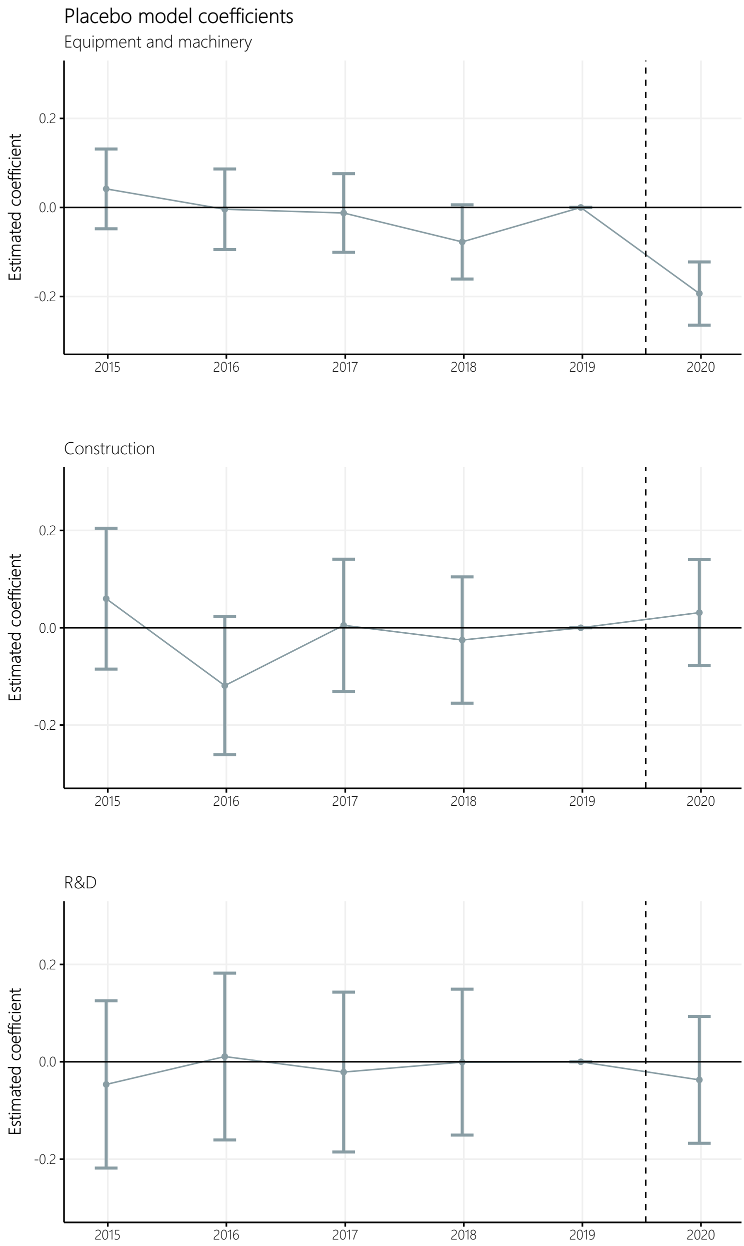

Figure 14: Placebo coefficients of the DD model. The figure depicts the series of placebo coefficients and the associated 90% confidence intervals. The placebo model estimates the interaction term for every period before and after the COVID-19 shock. Because I omit the interaction term for 2019 from the regression, each year's treatment effects are estimated relative to 2019, the year before the COVID-19 shock. The estimation sample covers the 2014–2020 period.

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Table 10: Robustness of baseline DD to alternative treatment dates

	Dependent variable:			
	Revisions in investment in equipment ($\Delta I_{i,t}$)			
	OLS			
	28 Feb	01 Mar	05 Mar	Gap (01 Mar - 16 Mar)
	(1)	(2)	(3)	(4)
T_t	−0.012	−0.010	−0.004	−0.009
	(0.045)	(0.044)	(0.038)	(0.044)
COVID_i	0.011	0.011	0.001	0.005
	(0.026)	(0.026)	(0.024)	(0.028)
$T_t \times \text{COVID}_i$	−0.087	−0.091*	−0.114**	−0.143**
	(0.055)	(0.055)	(0.052)	(0.059)
Industry fixed effects	Yes	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes	Yes
Observations	3,318	3,318	3,318	2,709
R^2	0.029	0.030	0.031	0.038
Adjusted R^2	0.004	0.004	0.005	0.008
Residual Std. Error	0.590 (df = 3233)	0.590 (df = 3233)	0.590 (df = 3233)	0.602 (df = 2625)
F Statistic	1.169 (df = 84; 3233)	1.172 (df = 84; 3233)	1.217* (df = 84; 3233)	1.255* (df = 83; 2625)
Note:				*p<0.1; **p<0.05; ***p<0.01
				Control variables are included but coefficients not reported.
				Cluster-robust standard errors in parenthesis.

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that my results are not driven by any specific treatment date and lends further plausibility to my choice of identification assigning firms into exposed and non-exposed to the COVID shock.

Second, I provide evidence that the baseline DD results do not depend on the exclusion of zero investments. One major concern with my estimates is that revisions from or to zero are discarded from the estimation sample because I define investment revisions as log differences. This is a particular worry for investment in construction as well as R&D because many firms do have zero expenditures on these types of investments in many years. This could be particularly relevant at the current edge.

To address this issue, I define an alternative outcome variable. In particular, I construct an ordered categorical variable equal to 1 if investment plans for any given year t increase (including increases from zero) between the autumn survey in $t-1$ and the spring survey in t, equal to -1 if they decrease (including decreases to zero) and equal to 0 if they remain unchanged. Using this variable as the outcome of an ordered logit model similar to the baseline DD model, Table 11 shows the results of this alternative estimation specification.

Table 11: Robustness of baseline DD to zero investments

	Investment revisions (categorical)		
	Equipment	Construction	R&D
	ordered logistic	*ordered logistic*	*ordered logistic*
	(1)	(2)	(3)
T_t	−0.049	−0.056	0.050
	(0.093)	(0.097)	(0.120)
COVID_i	−0.088	−0.020	0.140
	(0.066)	(0.071)	(0.091)
$T_t \times \text{COVID}_i$	−0.242*	−0.138	−0.397**
	(0.128)	(0.135)	(0.165)
Industry fixed effects	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes
Observations	4,436	4,318	3,738
Note:			*p<0.1; **p<0.05; ***p<0.01

The estimated coefficient on investment in equipment and machinery (Column 1) is again negative and statistically significant. As a result of the COVID-19 pandemic, the odds for an increase in investments in equipment have fallen by 22 percent. I further find a negative effect of the pandemic for R&D investments (Column 2). The odds for an increase in R&D investments have fallen by 31 percent. This result suggests that many companies may have canceled their investments in R&D completely during the crisis instead of just reducing them. Albeit negative, the effect on construction is not statistically significant (Column 3).

7 Conclusion

This paper has studied how the COVID-19 pandemic affected firms' investment decisions, combining a survey of Swiss firms with a quasi-experimental research design. It finds that the pandemic caused firms to reduce their 2020 investment plans by over one-eighth. Firms in regions more exposed to the virus and industries more sensitive to government-imposed restrictions cut their investments more. Both financial constraints and increased uncertainty contributed to downward revisions, which concern investments to extend the production capacity above all. By contrast, the pandemic stimulated investments driven by technological factors or investments of innovative firms.

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Appendices

A The COVID-19 pandemic in Switzerland

This appendix presents a timeline of selected events and measures taken by the Swiss federal government in the onset of the COVID-19 pandemic in Switzerland.

29 January	The Federal Department of Home Affairs defined qualified suspicion of disease and (positive and negative) detection on severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) as reportable.
28 February	The Swiss Federal Council categorizes the situation in Switzerland as *special* in terms of the Epidemics Act. Events with more than 1,000 people are prohibited effective immediately. Directly affected were, among others, sporting events, concerts, or the Basel Carnival. Cantonal authorities decided regionally on events with less than 1,000 people.
1 March	The Federal Office of Public Health launched a campaign with hygiene recommendations to protect against SARS-CoV-2.
13 March	The government announces the closure of the schools from Monday, 16 March. Events with more than 100 people are prohibited. Restaurants, bars, and discos are limited to 50 people. Ski resorts had to suspend operations.
15 March	The parliament decided not to proceed with the ongoing spring session.

16 March	Federal President declares the *extraordinary situation*, allowing the Federal Council to order uniform measures in all cantons. All public and private events are prohibited. Shops, restaurants, and leisure facilities must close. The lockdown also applies to schools and businesses where the recommended distance cannot be maintained (e.g. hairdressers and cosmetics studios). Only grocery stores and health facilities remain open. Border controls at the borders with Germany, Austria, and France were introduced, and entry bans were imposed, albeit with exceptions. Border checks at the Italian border were already introduced at an earlier stage. Up to 8,000 members of the armed forces were deployed to assist the cantons at hospitals and with logistics and security.
20 March	The Federal Council announced a comprehensive package of measures worth 32 billion Swiss francs to mitigate the economic consequences of the spread of the coronavirus. These include liquidity support for companies ("COVID-19 bridging credits"), expansion and simplification of short-time work, and compensation for loss of earnings for self-employed.
8 April	The Federal Council extended the measures taken on 16 March by one week (until 26 April) and announced to relax them in stages, starting before the end of April
16 April	Four weeks into the lockdown, the Federal Council announced the roadmap for easing its measures taken. The reopening of the economy and social life is to take place in three stages, see 27 April, 11 May and 6 June.
27 April	First step: hairdressers, DIY stores, and garden centers may resume operations with protection concepts.
11 May	Second step: Shops, restaurants, public markets, and museums may reopen. Primary and secondary schools can again teach on-site.
6 June	Third step: Events with up to 300 people are permitted again. Mountain railways, camping sites, zoos, and leisure facilities may open. Secondary, vocational, and higher education establishments may resume teaching.
15 June	The borders to all states within the EU/EFTA area will be opened completely. Among other things, shopping tourism to Germany or Austria is permitted again.
19 June	Return from the extraordinary to the special situation. The cantons will have a greater say and more room for maneuver. In public spaces, the minimum distance is reduced from 2 to 1.5 meters. Restaurants will be allowed to move their tables closer together, while at the same time, the Swiss midnight curfew will be lifted. Meetings and events for up to 1,000 people are again permitted. Masks are compulsory at rallies. The recommendation to work from home if possible is repealed.

Table 12: Timeline of selected events and measures taken by the Swiss federal government in the onset of the COVID-19 pandemic. Compiled from the ordinances and media releases of the Swiss Federal Council, see https://www.admin.ch/gov/en/start/documentation.html.

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B Data

This appendix gives more details on the Investment Survey conducted by the KOF Swiss Economic Institute at ETH Zurich.

The survey is conducted bi-annually since 2012 among a large panel of private Swiss firms. It takes place in the spring and autumn of each year and is available in all three official languages of Switzerland (German, French and Italian) as well as in English. Respondents may choose to fill out the questionnaire on paper or directly on the internet.

The panel of firms is a (with respect to firm size) disproportionately stratified sample, drawn from the national census of enterprises. To deal with attrition, new companies are regularly drawn from the census and included in the survey. Currently, it consists of 13,287 firms. The firms in the sample cover all industries excluding agriculture (NACE 10–96) and within each industry three size classes with complete coverage of large firms. The limits for the three size classes, which are defined by employment in full-time equivalents (FTE), are determined by "optimal stratification", taking firms' size distribution within industries into account (see Cochran, 2007). Overall, the sample accounts for 58% of total employment (FTE) in Switzerland.

The Investment Survey serves to identify investment tendencies at an early stage. For this purpose, it consists of many of qualitative and quantitative questions on investment plans and objectives, on the structure of investments, or the factors influencing investment activity. Investments are defined as gross fixed capital formation (GFCF). The survey distinguishes between investments in construction, machinery and equipment, as well as research and development. As part of the quality assurance of the data, all quantitative survey responses are subjected to plausibility checks. These involve rough checks to detect apparent errors in response behavior. For example, responses often vary in increments of thousands or millions across survey waves. Such inconsistencies can be easily identified and corrected thanks to the reporting and data structure. None of the main results critically depend on these corrections, but they tend to be more precisely estimated. As a robustness check, Table 24 shows estimates of the main specification without these corrections and after excluding all outliers below the 5th and above the 95th percentiles.

The analysis is based on data from all surveys conducted since 2012, focusing on data from the survey waves in autumn 2019 and spring 2020 to investigate the revisions in firms' investment plans in response to the Covid-19 pandemic. Table 13 summarises information on survey participants and response rates to the Investment Surveys in autumn 2019 and spring 2020. Columns 1 and 2 show the number of firms contacted in each wave. Columns 3 and 4 show the response rates. Column 5 gives the number of firms remaining in the joint sample. Column 6 reports the sectoral distribution in the final data set.

Table 13: Survey participants and response statistics

	Contacted firms		Response rates		Joint sample	
	Autumn 2019	Spring 2020	Autumn 2019	Spring 2020	N	%
Manufacturing	4328	4232	25%	23%	424	35%
Construction	1158	1135	23%	22%	75	6%
Services	8129	7886	26%	24%	701	58%
Overall	13615	13253	25%	23%	1200	100%

Survey participants and response rates to the Investment Surveys in Autumn 2019 and Spring 2020. Columns 1 and 2 show the number of firms contacted in each wave. Columns 3 and 4 show the response rates. Column 5 gives the number of firms remaining in the joint sample, i.e. the firms which reported investment figures for 2020 in both waves via the online survey. Column 6 reports the sectoral distribution in the final data set.

The survey in autumn 2019 was conducted from 30 September to 31 December 2019. From 13,650 contacted firms, 3,340 valid questionnaires were received, corresponding to a response rate of 24.5%. Of the participating firms, 30.7% are in manufacturing, 7.7% in construction, and 61.2% in the services

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sector.
In spring 2020, the survey was conducted from 25 February to 31 May 2020. From the 13,287 firms that were contacted, 3,103 valid questionnaires were received, corresponding to a response rate of 23.4%. Firms in the manufacturing, construction, and services sectors account for 31.0%, 7.9%, and 60.6% respectively of the participants in this wave.

Average response rates are similar across sectors and the final data set is balanced with respect to the distribution among the firms initially contacted. 33% of firms belong to the manufacturing sector (NACE 10–33). 6% of the firms in the sample are in construction (NACE 41–43) and 57% belong to the service sector (NACE 45–96). In terms of size, 27% of all firms are large firms (more than 250 FTE), 28% are medium-sized firms (between 50 and 249 FTE) and 45% of all firms in the sample have less than 50 employees. The median firm size is 74 employees. Unlike other surveys, the Investment Survey also includes micro-sized companies with only one employee.

Identification of non-response bias in survey data Wallace and Mellor (1988) outline methods to identify non-response bias in survey data. One proposition is to compare the profile of early respondents to the profile of late respondents, with the underlying presumption that late responders are similar to non-responders. In this table, I compare the first N respondents to the last N respondents of every spring survey. I select several N to avoid accidental outcomes. For each N, I test the equality of means between the two groups for several characteristics. I use a two-sided t-test allowing for unequal variances to test for equality of means. As shown in the table, no significant differences exist.

Variable	N	Mean (First N)	SD (First N)	Mean (Last N)	SD (Last N)	p-Value
Employees (FTE)	10	103.40	159.79	153.55	274.43	0.358
	25	98.99	139.20	150.12	241.33	0.087
	50	112.02	166.69	136.58	234.51	0.247
	100	138.39	243.88	137.83	227.06	0.974
$\text{irreversible}_{i,t}$	10	0.36	0.49	0.40	0.50	0.711
	25	0.35	0.48	0.46	0.50	0.097
	50	0.38	0.49	0.37	0.48	0.824
	100	0.34	0.47	0.34	0.48	0.837
$\text{uncertain}_{i,t}$	10	-0.95	0.85	-0.71	1.11	0.290
	25	-0.92	0.92	-0.65	1.16	0.073
	50	-0.98	0.92	-0.83	1.08	0.133
	100	-0.98	0.94	-0.90	1.04	0.239
$\log(I_{i,t,s=\text{spring } t})$	10	12.99	1.49	12.29	2.31	0.154
	25	12.95	1.60	12.50	2.31	0.146
	50	12.75	1.73	12.38	2.35	0.116
	100	12.39	2.09	12.56	2.36	0.366
$\Delta I_{i,t}$	10	0.06	0.42	0.00	0.65	0.747
	25	-0.04	0.50	-0.05	0.64	0.933
	50	0.02	0.56	-0.01	0.54	0.661
	100	0.01	0.55	-0.06	0.52	0.138

Difference between online and paper survey respondents This table provides a detailed breakdown of the sample into online and paper survey respondents by firm characteristics (size, location, export orientation, and industry) and the main variables used in the analysis. Unless otherwise stated, numbers are relative frequencies. The stars indicate if the means are significantly different at conventional level (***p $<$ 0.01, **p $<$ 0.05, *p $<$ 0.1). The underlying p-values result from a comparison of online and paper survey respondents with a two-sample t-test assuming unequal variance.

C Results

In this appendix, I present additional results including tables, figures, and sensitivity checks that are not featured in the main body of the paper. The subappendices refer to the corresponding sections in the main text.

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Table 14: Characteristics of online versus paper survey respondents

Variables	Online respondents (2014–2020)	Paper respondents (2014–2020)	
Firm size			
Small	0.41	0.48	***
Medium	0.32	0.35	
Large	0.26	0.17	***
Number of FTE	354.40	312.06	
Region			
Zurich	0.21	0.22	
Schweizer Mittelland	0.18	0.16	
Lake Geneva Region	0.10	0.14	**
Eastern Switzerland	0.20	0.16	**
Ticino	0.08	0.06	**
North-West Switzerland	0.12	0.13	
Central Switzerland	0.12	0.13	
Export orientation			
Exporter	1.31	1.25	**
Sector			
Manufacturing	0.33	0.32	
Construction	0.06	0.07	
Service	0.57	0.59	
Investments $I_{i,t}$ (log)			
GFCF	13.40	12.69	***
Equipment	12.88	12.21	***
Construction	13.37	12.61	***
R&D	11.95	11.63	
Investment revisions $\Delta I_{i,t}$			
GFCF	0.01	-0.04	
Equipment	-0.02	-0.02	
Construction	-0.01	-0.04	
R&D	-0.00	-0.06	
uncertain (1 if very/fairly uncertain)	0.14	0.16	*
$\text{irreversible}_{i,t}$	0.36	0.33	
Observations	2403	2645	

C.1 Descriptive evidence

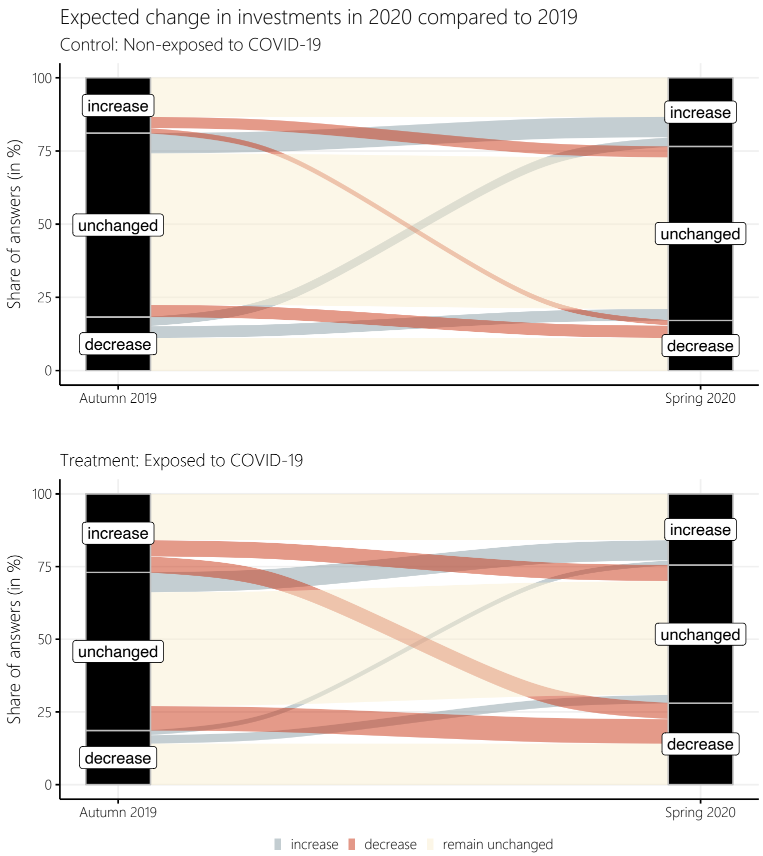

Figure C.1: Sankey diagram of firms' planned changes in investment in construction in 2020 relative to 2019 as collected in the Investment Surveys in autumn 2019 and spring 2020. Flows are shown separately for firms in the control (upper panel) and treatment group (lower panel).

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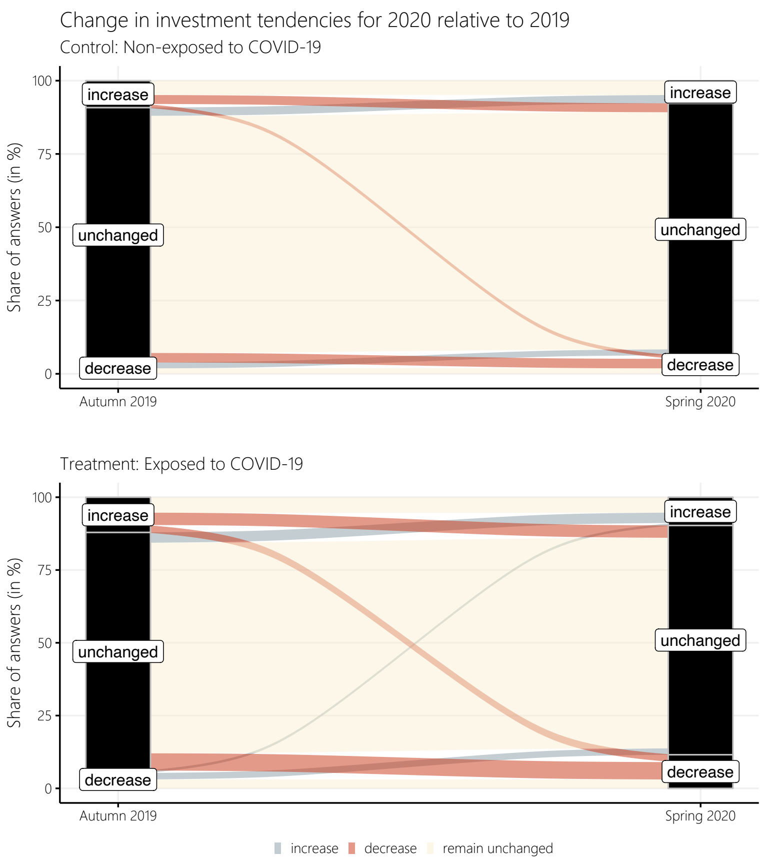

Figure C.2: Sankey diagram of firms' planned changes in investment in research and development in 2020 relative to 2019 as collected in the Investment Surveys in autumn 2019 and spring 2020. Flows are shown separately for firms in the control (upper panel) and treatment group (lower panel).

C.2 The overall impact of the pandemic on firms' investment plans

Purpose of investments To gain insight into which investment projects were abandoned due to the COVID shock, I examine how the pandemic influenced firms' motives to invest. Here, I construct an indicator that equals one if a firm no longer allocates its investment to a purpose it did intend in the previous survey and zero otherwise. Using logistic regressions, I am thus able to examine the probability of canceling specific investment projects due to the pandemic. In contrast to the probability of launching specific investment projects in Table 4, the regression results do not turn out significant; see Table 15. I interpret these differences in such a way that companies do not entirely abandon intended investment purposes but reduce them in scope. If planned, motives were not completely abandoned during the crisis. If not planned, certain motives were not additionally pursued.

C.3 The heterogeneous responses across firms

Investment revisions by firm characteristics, conditional treatment effects Table 16 is the regression counterpart of Figure 11, Panel A. It shows conditional treatment effects by sectors.

Table 15: DD estimates of the effect of the COVID-19 shock on investment motives (canceling)

	Purpose of canceled investments			
	Replacement	Extension	Streamlining	Environment
	logistic	*logistic*	*logistic*	*logistic*
	(1)	(2)	(3)	(4)
T_t	-1.132^{***}	-0.263	-0.384^{**}	-0.283
	(0.206)	(0.187)	(0.185)	(0.242)
COVID_i	0.009	0.013	0.096	0.079
	(0.102)	(0.123)	(0.129)	(0.170)
$T_t \times \text{COVID}_i$	0.305	-0.047	0.068	0.247
	(0.267)	(0.248)	(0.254)	(0.310)
Industry fixed effects	Yes	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes	Yes
Observations	3,488	1,975	1,761	1,062
Log Likelihood	-1,521.895	-1,108.678	-1,064.289	-636.559
Akaike Inf. Crit.	3,215.791	2,383.356	2,288.579	1,427.119

Note: *p<0.1; **p<0.05; ***p<0.01
Control variables are included but coefficients not reported.
Cluster-robust standard errors in parenthesis.

Table 16: Conditional treatment effects, by sector (Panel A)

	Dependent variable:			
	Revisions in investment in equipment ($\Delta I_{i,t}$)			
	Construction	Services	Manufacturing	Life sciences
	(1)	(2)	(3)	(4)
T_t	0.020	-0.036	0.048	-0.147
	(0.129)	(0.033)	(0.038)	(0.133)
COVID_i	-0.019	0.012	0.039	-0.028
	(0.125)	(0.049)	(0.058)	(0.138)
$T_t \times \text{COVID}_i$	-0.221	-0.183^{***}	-0.173^{**}	0.350
	(0.187)	(0.067)	(0.080)	(0.228)
Industry fixed effects	No	No	No	No
Region fixed effects	Yes	Yes	Yes	Yes
Observations	194	1,755	1,247	107
R^2	0.031	0.017	0.030	0.160
Adjusted R^2	-0.028	0.011	0.021	0.062
Residual Std. Error	0.578 (df = 182)	0.599 (df = 1743)	0.581 (df = 1235)	0.469 (df = 95)
F Statistic	0.529 (df = 11; 182)	2.761^{***} (df = 11; 1743)	3.436^{***} (df = 11; 1235)	1.640^{*} (df = 11; 95)

Note: *p<0.1; **p<0.05; ***p<0.01

Figure C.3 shows the sectoral decomposition per industry (NACE, Rev. 2 divisions) in greater detail.

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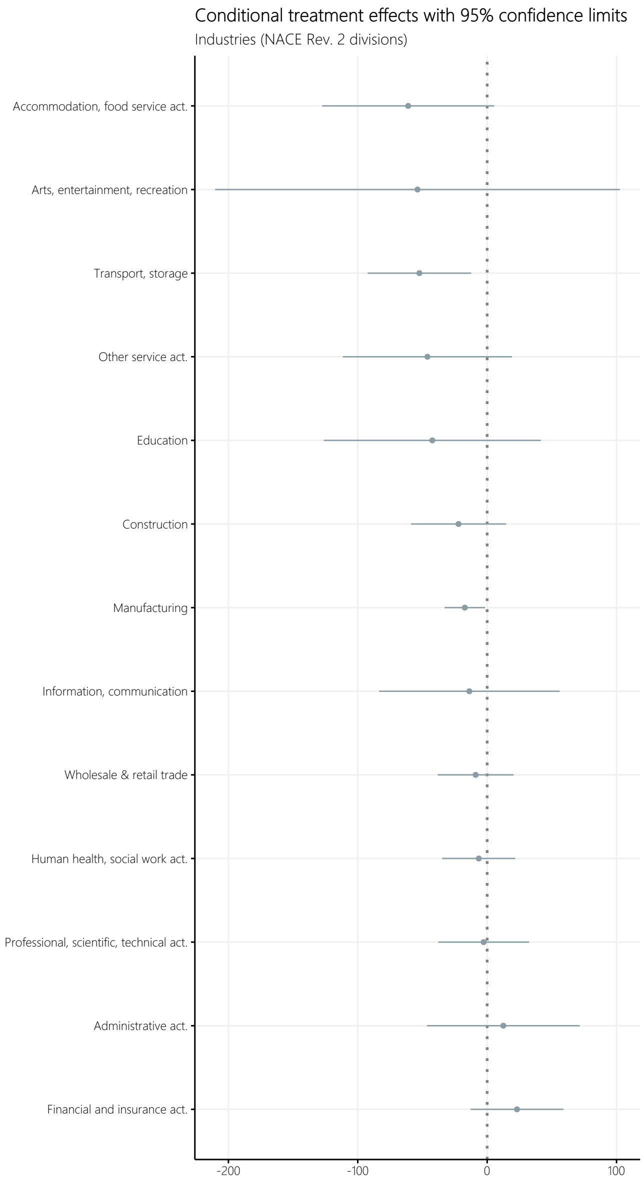

Figure C.3: Conditional treatment effects of the COVID-19 pandemic on firms' investment plans: difference-in-differences evidence. The figure shows regression results by industries

Table 17 is the regression counterpart of Figure 11, Panel B. It shows conditional treatment effects by firm size.

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Table 17: Conditional treatment effects, by firm size (Panel B)

	Dependent variable:	
	Revisions in investment in equipment ($\Delta I_{i,t}$)	
	SMEs	Large firms
	(1)	(2)
T_t	−0.001	0.0005
	(0.031)	(0.043)
COVID_i	0.028	−0.023
	(0.043)	(0.060)
$T_t \times \text{COVID}_i$	−0.215***	−0.021
	(0.059)	(0.082)
Industry fixed effects	Yes	Yes
Region fixed effects	Yes	Yes
Observations	2,458	860
R^2	0.051	0.062
Adjusted R^2	0.018	-0.008
Residual Std. Error	0.619 (df = 2375)	0.483 (df = 799)
F Statistic	1.564*** (df = 82; 2375)	0.883 (df = 60; 799)
Note:		*p<0.1; **p<0.05; ***p<0.01

Table 18 is the regression counterpart of Figure 11, Panel C. It shows conditional treatment effects by firm age.

Table 18: Conditional treatment effects, by firm age (Panel C)

	Dependent variable:	
	Revisions in investment in equipment ($\Delta I_{i,t}$)	
	Old (> 70 years)	Young (< 70 years)
	(1)	(2)
T_t	0.106**	−0.035
	(0.047)	(0.043)
COVID_i	0.085	−0.030
	(0.071)	(0.064)
$T_t \times \text{COVID}_i$	−0.342***	−0.075
	(0.093)	(0.086)
Industry fixed effects	Yes	Yes
Region fixed effects	Yes	No
Observations	937	1,201
R^2	0.069	0.052
Adjusted R^2	0.011	0.001
Residual Std. Error	0.550 (df = 881)	0.602 (df = 1138)
F Statistic	1.192 (df = 55; 881)	1.016 (df = 62; 1138)
Note:		*p<0.1; **p<0.05; ***p<0.01

Table 19 is the regression counterpart of Figure 11, Panel D. It shows conditional treatment effects by export orientation.

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Table 19: Conditional treatment effects, by export (Panel D)

	Dependent variable:	
	Revisions in investment in equipment ($\Delta I_{i,t}$)	
	Exporter	Non-exporter
	(1)	(2)
T_t	0.049	−0.016
	(0.046)	(0.032)
COVID_i	0.064	0.035
	(0.068)	(0.042)
$T_t \times \text{COVID}_i$	−0.205**	−0.159***
	(0.090)	(0.058)
Industry fixed effects	Yes	Yes
Region fixed effects	Yes	No
Observations	1,062	2,031
R^2	0.058	0.052
Adjusted R^2	-0.004	0.014
Residual Std. Error	0.592 (df = 995)	0.579 (df = 1952)
F Statistic	0.930 (df = 66; 995)	1.380** (df = 78; 1952)
Note:		*p<0.1; **p<0.05; ***p<0.01

Regional variation and exposure to the virus, conditional treatment effects Table 20 is the regression counterpart of Figure 12. It shows conditional treatment effects by regions.

Table 20: Conditional treatment effects, by region

	Dependent variable:						
	Revisions in investment in equipment ($\Delta I_{i,t}$)						
	Ticino	North-West Switzerland	Lake Geneva Region	Schweizer Mittelland	Zurich	Eastern Switzerland	Central Switzerland
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
T_t	−0.234	0.214**	0.091	0.073	−0.024	−0.134**	−0.014
	(0.205)	(0.086)	(0.125)	(0.061)	(0.063)	(0.059)	(0.070)
COVID_i	0.107	0.203**	0.113	0.030	−0.032	−0.087	−0.005
	(0.205)	(0.094)	(0.141)	(0.078)	(0.083)	(0.075)	(0.089)
$T_t \times \text{COVID}_i$	−0.527**	−0.527***	−0.214	−0.174	−0.144	−0.034	−0.030
	(0.249)	(0.142)	(0.174)	(0.109)	(0.114)	(0.106)	(0.124)
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region fixed effects	No	No	No	No	No	No	No
Observations	189	441	337	591	677	679	404
R^2	0.217	0.126	0.207	0.087	0.102	0.099	0.185
Adjusted R^2	0.032	0.012	0.068	-0.006	0.024	0.025	0.075
Residual Std. Error	0.673 (df = 152)	0.598 (df = 389)	0.611 (df = 286)	0.555 (df = 536)	0.604 (df = 622)	0.575 (df = 627)	0.504 (df = 355)
F Statistic	1.172 (df = 36; 152)	1.102 (df = 51; 389)	1.493** (df = 50; 286)	0.940 (df = 54; 536)	1.313* (df = 54; 622)	1.344* (df = 51; 627)	1.683*** (df = 48; 355)
Note:							*p<0.1; **p<0.05; ***p<0.01

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C.4 Placebo and main sensitivity checks

Percentage investment revisions One primary concern with my main specification is that revisions from or to zero are discarded from the estimation sample because the log of zero is undefined. This table presents robustness checks in which I use an alternative outcome variable. In particular, instead of defining investment revisions as log differences, I calculate them as percentage changes.

Table 21: Robustness of baseline DD to percentage investment changes

	Investment revisions ($\Delta I_{i,t}$)		
	Equipment	Construction	R&D
	OLS	*OLS*	*OLS*
	(1)	(2)	(3)
T_t	3.838	14.068	18.883*
	(5.126)	(12.661)	(10.084)
COVID$_i$	−0.643	5.130	−2.330
	(3.404)	(6.291)	(5.833)
$T_t \times$ COVID$_i$	−12.701*	−19.108	−6.899
	(7.087)	(15.354)	(14.091)
Industry fixed effects	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes
Observations	3,482	2,043	1,108
R^2	0.028	0.035	0.087
Adjusted R^2	0.004	-0.004	0.023
Residual Std. Error	85.101 (df = 3396)	122.252 (df = 1963)	89.174 (df = 1034)
F Statistic	1.153 (df = 85; 3396)	0.891 (df = 79; 1963)	1.358** (df = 73; 1034)

Note: *p<0.1; **p<0.05; ***p<0.01
Control variables are included but coefficients not reported.
Cluster-robust standard errors in parenthesis.

$\log(1 + x)$ transformation One primary concern with my main specification is that revisions from or to zero are discarded from the estimation sample because the log of zero is undefined. This table presents robustness checks in which I use an alternative outcome variable. In particular, instead of defining investment revisions as log differences, I calculate them as $\log(1 + x)$ differences.

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Table 22: Robustness of baseline DD to log(1+x) transformation

	Investment revisions ($\Delta I_{i,t}$)		
	Equipment	Construction	R&D
	OLS	*OLS*	*OLS*
	(1)	(2)	(3)
T_t	−0.144	−0.110	−0.049
	(0.166)	(0.208)	(0.160)
COVID_i	−0.008	0.212	0.054
	(0.130)	(0.171)	(0.132)
$T_t \times \text{COVID}_i$	−0.490**	−1.001***	−0.307
	(0.233)	(0.300)	(0.225)
Industry fixed effects	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes
Observations	4,225	4,121	3,573
R^2	0.026	0.028	0.027
Adjusted R^2	0.006	0.008	0.003
Residual Std. Error	3.521 (df = 4138)	4.485 (df = 4034)	3.102 (df = 3486)
F Statistic	1.306** (df = 86; 4138)	1.371** (df = 86; 4034)	1.120 (df = 86; 3486)

Note: *p<0.1; **p<0.05; ***p<0.01
Control variables are included but coefficients not reported.
Cluster-robust standard errors in parenthesis.

Inclusion of paper survey respondents This table presents robustness checks in which I include paper survey respondents into the estimation sample. In my main specification, I exclude all paper survey participants and only retain the answers of those participants who completed the survey online. At the cost of fewer observations, this allows me to determine the exact time of response, which proves necessary for identification as part of the empirical strategy (see Section 4).

Table 23: Robustness of baseline DD to the inclusion of paper survey respondents

	Investment revisions ($\Delta I_{i,t}$)			
	GFCF	Equipment	Construction	R&D
	OLS	*OLS*	*OLS*	*OLS*
	(1)	(2)	(3)	(4)
T_t	0.006	−0.005	0.004	0.056
	(0.040)	(0.032)	(0.055)	(0.055)
COVID_i	−0.015	0.011	−0.002	−0.011
	(0.027)	(0.021)	(0.035)	(0.041)
$T_t \times \text{COVID}_i$	−0.180***	−0.146***	−0.030	−0.057
	(0.052)	(0.044)	(0.071)	(0.076)
Industry fixed effects	Yes	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes	Yes
Observations	4,872	4,393	2,314	1,225
R^2	0.028	0.026	0.026	0.080
Adjusted R^2	0.010	0.007	-0.009	0.021
Residual Std. Error	0.767 (df = 4786)	0.600 (df = 4307)	0.683 (df = 2233)	0.591 (df = 1150)
F Statistic	1.604*** (df = 85; 4786)	1.379** (df = 85; 4307)	0.737 (df = 80; 2233)	1.351** (df = 74; 1150)

Note: *p<0.1; **p<0.05; ***p<0.01
Control variables are included but coefficients not reported.
Cluster-robust standard errors in parenthesis.

Exclusion of manual data plausibility checks This table presents robustness checks in which I use data that were not subjected to manual plausibility checks. As part of the quality assurance of the data, all quantitative survey responses are usually subjected to plausibility checks. These involve rough checks to detect obvious errors in response behavior. For example, responses often vary in increments of thousands or millions across survey waves. Such inconsistencies can be easily identified and corrected thanks to the reporting and data structure. None of the main results critically depend on these correc-

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tions, but they tend to be more precisely estimated. As a robustness check, this table shows estimates of the main specification without these corrections and after excluding all outliers below the 5th and above the 95th percentiles.

Table 24: Robustness of baseline DD to exclusion of manual data plausibility checks

	Investment revisions ($\Delta I_{i,t}$)			
	GFCF	Equipment	Construction	R&D
	(1)	(2)	(3)	(4)
T_t	0.042	0.033	−0.028	0.039
	(0.031)	(0.034)	(0.050)	(0.071)
COVID$_i$	−0.023	−0.005	−0.041	−0.009
	(0.021)	(0.023)	(0.035)	(0.049)
$T_t \times$ COVID$_i$	−0.109**	−0.143***	0.028	0.030
	(0.044)	(0.048)	(0.067)	(0.090)
Constant	0.026*	−0.009	0.029	−0.029
	(0.015)	(0.016)	(0.027)	(0.037)
Industry fixed effects	Yes	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes	Yes
Observations	3,499	3,176	1,707	914
R^2	0.004	0.005	0.001	0.002
Adjusted R^2	0.003	0.004	-0.001	-0.001
Residual Std. Error	0.541 (df = 3495)	0.569 (df = 3172)	0.615 (df = 1703)	0.619 (df = 910)
F Statistic	4.774*** (df = 3; 3495)	5.557*** (df = 3; 3172)	0.522 (df = 3; 1703)	0.549 (df = 3; 910)

Note: *p<0.1; **p<0.05; ***p<0.01
Control variables are included but coefficients not reported.
Cluster-robust standard errors in parenthesis.

Weighted regressions This table presents robustness checks in which I weight each firm with the number of its employees (FTE).

Table 25: Robustness of baseline DD to employee-weighted regressions

	Investment revisions ($\Delta I_{i,t}$)			
	GFCF	Equipment	Construction	R&D
	OLS	*OLS*	*OLS*	*OLS*
	(1)	(2)	(3)	(4)
T_t	0.062	0.030	0.054	0.082
	(0.047)	(0.041)	(0.050)	(0.061)
COVID$_i$	−0.009	−0.058	0.075	0.084
	(0.051)	(0.047)	(0.089)	(0.065)
$T_t \times$ COVID$_i$	−0.159*	−0.014	−0.092	−0.111
	(0.084)	(0.083)	(0.106)	(0.084)
Industry fixed effects	Yes	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes	Yes
Observations	3,664	3,318	1,788	963
R^2	0.082	0.075	0.067	0.216
Adjusted R^2	0.061	0.052	0.026	0.157
Residual Std. Error	10.278 (df = 3580)	8.450 (df = 3234)	11.661 (df = 1712)	6.424 (df = 894)
F Statistic	3.850*** (df = 83; 3580)	3.173*** (df = 83; 3234)	1.642*** (df = 75; 1712)	3.630*** (df = 68; 894)

Note: *p<0.1; **p<0.05; ***p<0.01
Control variables are included but coefficients not reported.
Cluster-robust standard errors in parenthesis.

Falsification test This table presents the results of a falsification test. In a causal analysis, it is common to test a very unlikely claim to be causally related to the intervention. In my case, I test whether firms' investment revisions for 2019 – rather than 2020 – are influenced by the COVID-19 pandemic. Investment in 2019 should not have been affected by the pandemic if it were to be truly exogenous. My model does not explain investment revisions for 2019. This adds a layer of confidence to my results, even if falsification analysis is not a perfect tool for validating causality.

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Table 26: Robustness of baseline DD to the falsification test

	Investment revisions ($\Delta I_{i,t}$)			
	GFCF	Equipment	Construction	R&D
	(1)	(2)	(3)	(4)
T_t	−0.059	0.017	0.023	−0.016
	(0.050)	(0.035)	(0.060)	(0.062)
COVID_i	−0.023	0.012	−0.025	−0.045
	(0.034)	(0.027)	(0.044)	(0.049)
$T_t \times \text{COVID}_i$	−0.014	−0.068	0.004	0.058
	(0.063)	(0.050)	(0.077)	(0.083)
Industry fixed effects	Yes	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes	Yes
Observations	2,783	2,528	1,354	679
R^2	0.030	0.031	0.043	0.076
Adjusted R^2	0.001	-0.001	-0.011	-0.017
Residual Std. Error	0.733 (df = 2700)	0.559 (df = 2445)	0.639 (df = 1280)	0.518 (df = 616)
F Statistic	1.021 (df = 82; 2700)	0.969 (df = 82; 2445)	0.793 (df = 73; 1280)	0.812 (df = 62; 616)

Note: *p<0.1; **p<0.05; ***p<0.01
Control variables are included but coefficients not reported.
Cluster-robust standard errors in parenthesis.

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The sooner (and the smarter), the better: COVID-19 containment measures and fiscal responses[1]

Amr Hosny[2]

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This paper finds empirical evidence that faster and smarter containment measures were associated with lower fiscal responses to the COVID-19 shock. We also find that initial conditions, such as fiscal space, income, health preparedness and budget transparency were important in shaping the amount and design of the COVID-19 fiscal response.

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1 The views expressed in this paper are those of the author and do not necessarily represent the views of the IMF, its Executive Board, or IMF management. The author and manuscript benefi ed from useful comments and feedback from James Daniel, Alexander Tieman, Yuko Kinoshita, Zsuzsa Munkacsi, Catherine Pattill , Alexandra Fotiou, Andresa Lagerborg, Kenji Moriyama, Lahcen Bounader, Alexandre Balduino Sollaci, Fuad Hasanov, Hamid Davoodi, Hoda Selim, Adrian Peralta-Alva, Swarnali Ahmed Hannan, Philipp Engler, Lone Christiansen, Chris Redl, Jeromin Zettelmeyer, and Bas B. Bakker.

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I. INTRODUCTION AND CONTRIBUTION TO THE LITERATURE

COVID-19 is a health and economic shock. Since it was declared a global pandemic in early March 2020, many countries have seen more than one wave of infection outbreaks, and with it, waves of containment measures and central bank and government responses. This "Great Lockdown", as labeled by the IMF World Economic Outlook, is a supply and demand shock that has disrupted the cycle of production of goods and services, affecting households and businesses, big and small. Policymakers often struggled to balance their health and economic responses to the pandemic.

There is observational and empirical evidence that containment measures can reduce infections and fatalities. For example, Cowling et al (2020) in an observational study show that containment measures, or non-pharmaceutical interventions (NPIs), were effective in reducing the incidence of COVID-19 infections in Hong Kong between January and March 2020. IMF (2020), Deb et al (2020a) and Demirgüç-Kunt et al (2020) use empirical methods with high-frequency data to show that NPIs can be effective in reducing the number of infections and fatalities, especially when such measures were implemented faster.

A number of papers use the Susceptible, Infected and Recovered (SIR) epidemiology model and its variants to study the impact of hard/physical (quarantines) versus soft/smart[2] (testing) measures on health and economic outcomes. These models build on the original SIR epidemiology model by Kermack and McKendrick (1927) and adapt it to the economic literature. For example, Berger et al (2020) show that expanding testing in conjunction with targeted quarantine policies can dampen the economic fallout and reduce peak symptomatic infections – which is important for health infrastructure constraints. Acemoglu et al (2020), Brotherhood et al (2020) and Checo et al (2020) find similar results, focusing on targeted policies by age groups and high- versus low-risk individuals. Piguillem and Shi (2020) show that random testing can be a very close substitute for quarantines. Forslid and Herzing (2020) show that early quarantine essentially postpones, but does not alter, the course of infections at a cost that increases with the duration and extent of quarantine. They also model a trade-off between health and economic outcomes versus the duration of a quarantine. While their results imply that early quarantining may not be useful, lifting them earlier (potentially because of their success when implemented earlier) results in better health outcomes and less economic losses. Lattanzio and Palumbo (2020) emphasize the importance of soft containment measures, such as social distancing, wearing masks, sanitizing public and private spaces and generally increasing hygienic standards among others. Andrabi et al (2020) advocate the importance of smart real-time testing, contract tracing and community messaging. Cherif and Hasanov (2020) argue that implementing

[2] Throughout the paper, "smart" containment measures refer to elements such as testing, contact tracing and public health information campaigns.

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a universal testing strategy requires epidemiological testing—sacrificing test accuracy for scalability, convenience, and speed—and industrial policy to ramp up production of tests.

A number of papers have used high-frequency indicators to study the economic impact of COVID-19 in real-time. Examples include proxies for economic activity such as electricity usage, nitrogen dioxide emissions, mobility trends and job postings as in Chen et al (2020), Deb et al (2020a; 2020b), Demirgüç-Kunt et al (2020) and IMF (2020), respectively. For example, Debt et al (2020b) show that containment measures have had, on average, an impact on economic activity equivalent to a loss of about 15 percent in industrial production. Deb et al (2020a) and Demirgüç-Kunt et al (2020) further show that early introduction of NPIs can limit the economic fallout of the pandemic. Cevik and Öztürkkal (2020) using daily data find that more infections are associated with higher sovereign credit default swap (CDS) spreads.

This paper empirically examines the determinants of countries' fiscal measures in response to COVID-19, focusing on the role of (speed and type of) containment measures. Specifically, we regress governments' fiscal measures in response to COVID-19 on the observed public health response time (or PHRT: the speed of introducing stringency measures, defined below) among other control variables. Importantly, when defining stringency, we differentiate between "hard/physical" lockdowns and "soft/smart" measures that also include elements such as testing, contact tracing and public health information campaigns. We also examine the role of other control variables including the average stringency over the sample period, as well as measures of income, fiscal space, budget transparency, economic outlook and health preparedness. The sample period covers daily data on stringency indices between January 1st and October 15th. Data on fiscal measures in response to COVID-19 covers 190 countries, by type (above-the-line and below-the-line)[3] and comes from the IMF October 2020 Fiscal Monitor.

The main finding is that faster and smarter containment measures were associated with lower fiscal responses. Specifically, the faster the PHRT, the better. Moreover, the type of containment measures matters – physical lockdowns alone are less effective than those accompanied by smart measures. We also find that swift introduction of (especially smart) measures may reduce or even nullify the need to maintain on average higher restrictions in place over time. This is in line with the growing literature on the importance of early and smart NPIs (Aum et al 2020; Berget el al 2020; Cherif and Hasanov (2020); Deb et al 2020a; Fotiou and Lagerborg 2021a; IMF 2020). This suggests that there need not be a trade-off

[3] On budget "above-the-line" measures include additional spending (e.g. health spending, unemployment benefits, transfers) or forgone revenues (e.g. tax cuts and credits) provided through standard budget channels. Off-budget "below-the-line" measures include equity injections, asset purchases or loans, including through extra-budgetary funds. "Contingent liabilities" include government guarantees and other quasi-fiscal operations.

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between health and economic outcomes, and that the same measures that help save lives, can also save fiscal resources.

Other results highlight the important role of initial conditions in shaping the amount and design of the COVID-19 fiscal response. We find that fiscal space constrained the overall fiscal response, especially in non-health fiscal measures and in developing countries. We also find that fiscal packages were larger for higher-income countries, especially below-the-line measures, while lower-income countries spent more on health given their weaker initial health infrastructure and preparedness. Other health-related variables, such as cases per population and the share of elderly population, matter for the health fiscal response. Higher budget transparency is also found to be associated with a larger fiscal response, reflecting the importance of strong institutional and PFM capacity.

We contribute to the strand of the empirical literature on the economic impact of containment measures. Many of the above cited existing studies on the impact of the pandemic are model-based. This paper contributes to the small but rapidly expanding empirical literature on the topic as more data becomes available. We differentiate between physical and smart containment measures, emphasize the importance of the speed of enacting stringency measures, and study the impact of the type and speed of measures on government fiscal responses. Closest to our work is Fotiou and Lagerborg (2021a), but compared to that, we define "early" and "smart" containment measures in a way that more robustly captures the dynamics of governments' stringency responses (see below), use a more updated dataset (from Jan 1st till Oct 15th) on both stringency indices and fiscal measures, and control for more variables that can affect the size and composition of fiscal measures in response to COVID-19 in the empirical specifications. Fotiou and Lagerborg (2021b) study the impact of average and early containment, among other variables, on the WEO projection revisions of GDP growth, primary balance and debt-to-GDP. Balajee et al (2020) focus on the role of average stringency only and their measure of fiscal responses excludes below-the-line measures and tax deferrals and the sample period, over which average stringency is computed, stops on April 9th.

The rest of this paper is structured as follows. Section II presents stylized facts. Section III presents the empirical model and results. Finally, Section IV concludes.

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II. An Initial Look at the Data

Fiscal measures in response to COVID-19 varied by income level and by region. We use the October 2020 Fiscal Monitor database on country fiscal measures in response to COVID-19.[4] The dataset includes announced fiscal measures, in almost all IMF member countries, and are classified into on-budget above-the-line (ATL) health and non-health measures, tax deferrals and off-budget below-the-line (BTL) and contingent labilities (CLs such as guarantees and quasi-fiscal operations). ATL measures include both forgone revenues and additional spending, mostly to provide support to households, while BTL-CL measures are mostly to support firms.

- By income level, reported fiscal responses were highest in AEs, followed by EMs and LIDCs. Health responses were smaller than non-health and other measures, on average. This may suggest that, while COVID-19 is primarily a health crisis, containment measures and disruptions to economic activity meant financial resources had to be devoted more to protecting incomes of vulnerable households and liquidity of stressed businesses. That said, additional spending on health as a share of overall fiscal response was most sizable in LIDCs, reflecting their weaker initial overall health infrastructure and preparedness. BTL-CL measures were more pronounced in AEs, potentially given their stronger fiscal institutions.
- By region, the median announced fiscal response was the highest in European (EUR) countries, at around 10 percent of GDP. Countries in Asian-Pacific (APD) and Western Hemisphere (WHD) followed. The median fiscal response in Middle East and Central Asia (MCD) and African (AFR) countries was relatively the smallest, potentially reflecting weaker fiscal space going into the crisis. This hypothesis will be tested below.

Figure 1. Fiscal Responses, by Income Level
(Jan. 1 – Oct. 15, 2020, in percent of GDP)

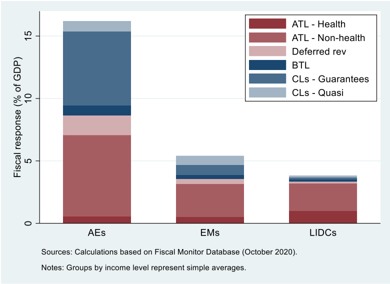
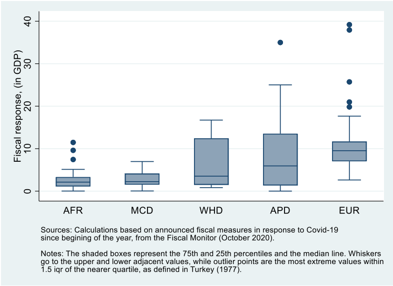


Figure 2. Fiscal Responses, by Region
(Jan. 1 – Oct. 15, 2020)



[4] Available at https://www.imf.org/en/Topics/imf-and-covid19/Fiscal-Policies-Database-in-Response-to-COVID-19. This is also reflected in the IMF Policy Tracker, available at https://www.imf.org/en/Topics/imf-and-covid19/Policy-Responses-to-COVID-19

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We use data from Oxford's COVID-19 Government Response Tracker (OxCGRT) for containment measures (Hale et al 2020).[5] Specifically, we use both the stringency index and the containment health index. The OxCGRT "stringency index" collects information on government policy responses across eight dimensions, namely: school closures; workplace closures; public event cancellations; gathering restrictions; public transportation closures; stay-at-home orders; restrictions on internal movement; and international travel bans. The OxCGRT "containment and health index" includes all the above plus testing policy, contact tracing and public health information campaigns. We use both indices to distinguish between "hard/physical" lockdown measures alone versus those accompanied by "soft/smart" public health measures.

We use the concept of public health response time to study the speed of countries' response to COVID-19. Fotiou and Lagerborg (2021a; 2021b) define early stringency as the OxCGRT stringency index in place when the 100th case was reported. Deb et al (2020a) define public health response time (PHRT) as the number of days it takes for a country to tighten containment measures after a significant outbreak (defined as 100 confirmed cases), using all NPIs in the OxCGRT stringency index other than international travel restrictions. IMF (2020) calculates the number of days to reach maximum stringency after the first reported case, and use the median of that sample to split countries into fast versus slow tighteners. In this paper, we define PHRT as the number of days it takes a country to reach its maximum stringency (measured by both the stringency and containment health indices) after a significant outbreak. Compared to existing studies:

- As in Deb et al (2020a) and Fotiou and Lagerborg (2021a; 2021b), we define a significant outbreak as 100 confirmed cases. Baldwin and di Mauro (2020) also use this threshold.
- However, we differ in the following aspects. First, we define PHRT as the number of days for each country's OxCGRT index to reach its "maximum" level over the sample period, not just the days to "increase" the index after a major outbreak (as in Deb et 2020a), and not just the value of the stringency index at 100 cases (as in Fotiou and Lagerborg 2021a; 2021b). Consider the example of countries A, B and C; whereby country A was the most prudent and reached its maximum stringency before 100 confirmed cases, whereas countries B and C had similar stringencies when they hit 100 cases, but imposed restrictions thereafter at different speeds and reached their maximum stringency weeks or months apart. Deb el al (2020a) would likely penalize country A, while Fotiou and Lagerborg (2021a; 2021b) would not be able to differentiate between countries B and C. In fact, using our *phrt* (*phrt_smart*) definitions, the country A situation is observed in about 21 percent of the sample, while the

[5] Available at https://www.bsg.ox.ac.uk/research/research-projects/coronavirus-government-response-tracker#data

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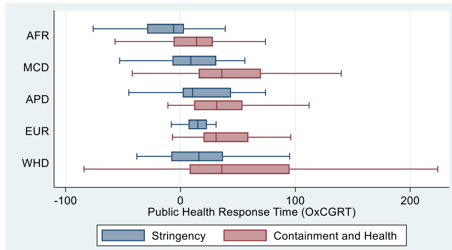
countries B and C situation is observed in about 70[6] percent of the sample. Second, we retain international travel restrictions in our measure of stringency (whereas Deb el al (2020a) drop it), as such restrictions have been shown to be effective (Chinazzi et al (2020) and Hsiang et al (2020)). Third, we use the containment and health index as is (whereas Fotiou and Lagerborg (2021a; 2021b) reconstruct it to separate out the health component).

Public health response times varied, by region and by type of restrictiveness. Using our definition of PHRT, AFR countries were the fastest to reach their maximum restrictiveness (using the OxCGRT stringency (blue bars) and the containment and health (red bars) indices). One reason for this could probably be because the COVID-19 wave reached AFR countries relatively late, allowing them to learn from the experiences of others and to put early stringency measures in place before infection cases reached a critical mass. Dispersion of the PHRT in WHD was the largest, suggesting a very heterogenous response at the country level, especially when using the containment and health index. While all regions were slower in enacting health and testing responses compared to lockdowns (median for red bars is uniformly higher than that of blue bars), the median PHRT for EUR improves, in comparison to other regions, suggesting they were relatively more aggressive on testing policies.

Figure 3. Public Health Response Time, by Region
(Jan. 1 – Oct. 15)

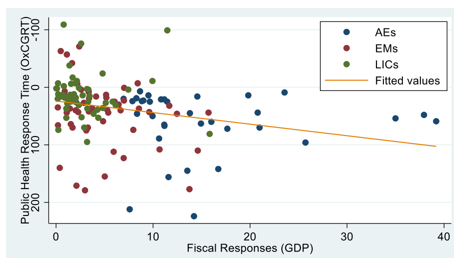


Sources: Calculations based on OxCGRT.

Notes: Public health response time (PHRT) is the numbers of days to reach the country's maximum restrictiveness (OxCGRT containment and health index) after a major outbreak (100 cases). The shaded boxes represent the 75th and 25th percentiles and the median line. Whiskers go to the upper and lower adjacent values, as defined in Turkey (1977).

Anecdotal evidence suggests that enacting containment and health measures faster is associated with lower fiscal responses. A visual examination of the data over the sample period suggests that faster PHRT is associated with lower fiscal responses in percent of GDP. We can also see that countries' income levels seem to be a relevant factor affecting the size of the fiscal response. The next section will empirically test this hypothesis, among other initial conditions and

Figure 4. Speed of Containment Measures and Fiscal Response
(Jan. 1 – Oct. 15)



Sources: Calculations based on OxCGRT and Fiscal Monitor (October 2020).

Notes: (i) Public health response time (PHRT) is the numbers of days to reach the country's maximum restrictiveness (OxCGRT containment and health index) after a major outbreak (100 cases); and (ii) Fiscal response, in percent of GDP, are announced fiscal measures in response to Covid-19 since begining of the year, from the Fiscal Monitor.

[6] This simply means that the example of countries B and C where two or more countries had about the same stringency index at 100 confirmed cases happened *collectively* in about 70 percent of the countries; *not* that 70 percent of the countries had the same stringency index at 100 confirmed cases.

control variables to study the determinants of fiscal measures in response to COVID-19.

III. The Empirical Model and Results

The methodology used is a cross-sectional regression to study how containment measures may affect the size of announced fiscal responses, accounting for other factors that may affect fiscal responses.[7] Sample period starts in January and ends in mid-October. We use the following specification where the dependent variable is a measure of the fiscal response as a share of GDP. Our basic specification uses the total (ATL+BTL+CL) fiscal response, but we also use ATL health and BTL-CL fiscal measures separately.

$$fiscalresponse_i = \beta_0 + \beta_1 phrt_i + \beta_2 avg_i + \beta_3 lgdppc_i + \beta_4 X_i + \varepsilon$$

The main coefficient of interest is the PHRT variable which measures how the speed and type of containment relates to the fiscal response. As described above, *phrt* measures the speed at which countries implement stringency measures. We expect the estimated coefficient to be positive, indicating that faster containment response (lower PHRT) is associated with smaller fiscal responses. We use both the OxCGRT stringency index to capture the effect of physical lockdowns (*phrt*) and the OxCGRT containment and health index to also capture the effect of smart measures such as testing policy and contact tracing (*phrt_smart*).

We also include each country's average containment response. The *phrt* and *phrt_smart* variables measure the speed at which each country reaches its maximum stringency index over the sample period. To measure how strict such stringency has been on average, we use the *avg* and *avg_smart* variables, i.e. the average of the country's OxCGRT daily stringency index and containment and health index, respectively, over the sample period. The estimated coefficient could be positive (especially for *avg*, indicating that higher (lockdown) measures are costly given more disruptions to economic activity), or negative (especially for *avg_smart* indicating that higher (smart) measures on average are less costly given they can potentially limit infections and allow for safer resumption of activity), or statistically insignificant, including because a faster (and smarter) containment response – measured by PHRT – may more quickly contain the spread of infections and as a result lead to earlier

[7] A panel methodology is not possible in this context, as time-series for the dependent variable (fiscal responses) is not available.

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easing of lockdown restrictions and resumption of economic activity, which could ultimately lower the required fiscal response.

Other control variables include the following:

- The (log of) **GDP per capita**, measured in real PPP terms from the October 2020 IMF WEO, to account for the role of income and the corresponding capacity of governments to issue fiscal support packages. The estimated coefficient could be positive for overall and BTL-CL fiscal responses (as richer countries spent relatively more on these categories), but negative for health responses (as poorer countries spent relatively more on health).
- **Fiscal space.** Alon et al (2020) incorporate fiscal space constraints to model the effectiveness of government lockdown measures in developing countries. Closer to our work, Balajee et al (2020) use credit ratings, while Fotiou and Lagerborg (2021a) use public debt, fiscal balances, grants and commodity revenues as measures of fiscal space. One can argue that all such elements may in a way be reflected in countries' spreads, and as such we use the (log of) Emerging Markets Bond Index (EMBI) spreads as a summary measure of fiscal space in this paper. We expect the estimated coefficient to be negative, indicating that less fiscal space constrained the fiscal response.
- **Budget transparency.** We use the 2019 Open Budget Survey (OBS) index as a measure of budget transparency.[8] The index measures transparency (the extent to which the government releases timely, comprehensive and useful budget information) as well as public participation and oversight institutions. Higher values of the index imply higher budget transparency. As such, we expect the estimated coefficient to be positive, especially in the BTL-CL specification.
- **Health-related variables.** We control for the number of infected **cases per population**. Data on number of cases comes from OxCGRT while data on total population comes from the World Bank WDI. We also control for **population ages 65** and above, as a share of total population, from the WDI. We expect the estimated coefficients of these variables to be positive, especially in the ATL health specification. Finally, we use the 2019 Global Health Security **(GHS) index** as a measure of the overall health infrastructure and preparedness of a country prior to the pandemic.[9] The index covers prevention (e.g. immunizations), detection and reporting (e.g. laboratory systems), response (e.g. planning and operations), health system (e.g. healthcare capacity and access), compliance with international norms (e.g. international agreements and commitments) and risk environment (e.g. infrastructure adequacy). Higher values of the index imply stronger initial health conditions. As such, we expect the estimated coefficient to be negative, especially in the ATL health specification.

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[8] Available at https://www.internationalbudget.org/open-budget-survey/

[9] Available at https://www.ghsindex.org/

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Empirical results are subject to caveats. First, establishing causality in this context is difficult because countries' decisions to implement containment measures depend on the evolution of the pandemic, which in turn affects countries' fiscal responses, which in turn may depend on success of containment measures. Regression results presented show associations, and correlation does not imply causation. Second, the dependent variable is total announced fiscal measures, which may differ from actual implementation, may have been announced in stages and may include a mix of discretionary measures and automatic stabilizers. Third, coverage may differ between general or central government or public sector, blurring the difference between ATL and BTL-CL measures in some cases. Fourth, some countries where the pandemic hit relatively later might have been able to learn from others who were hit earlier, affecting countries' PHRT. Finally, the OxCGRT index neither captures voluntary social distancing, which may affect infections (IMF 2020) and fiscal responses, nor any potential gaps between officially imposed and actually implemented stringency measures or their effectiveness. In what follows, table 1 presents results using the total (ATL health and non-health and BTL-CL) fiscal response as the dependent variable. Table 2 focuses on the ATL health fiscal response only, while table 3 studies the determinants of the BTL-CL (BTL financing and CLs) fiscal response. Table 4 presents some robustness checks.

Our main result is that faster, and smarter, containment was associated with smaller fiscal responses. The coefficient attached to the *phrt_smart* variable is positive and statistically significant. This result is robust in all reported specifications with different control variables and whether the dependent variable is the total (models 1-3), ATL health (models 7-9), or BTL-CL (models 13-14) fiscal response. When looking at the *phrt* variable alone which considers physical lockdowns only, however, the coefficient is not statistically different from zero in 6 of the 8 specifications in tables 1-3. The simple average of statistically significant *phrt_smart* coefficients in tables 1-4 is around +0.03, indicating that a 10 percent decrease in mean PHRT is associated with a lower fiscal stimulus by 0.3 percent of GDP, holding all else constant.[10] This highlights the importance of not only acting fast, but also acting smart. It is consistent with the growing literature on the importance of smart measures. For example, Aum et al (2020), Berger et al (2020) and Cherif and Hasanov (2020) use variants of the SIR model to show that testing and tracking can more effectively reduce infections and disrupt the economy less than a blanket lockdown. Empirically, Deb et al (2020a) and IMF (2020) find evidence that countries with faster PHRT had a significant impact on infections and mortality. Focusing on economic outcomes, Fotiou and Lagerborg (2021b) find that countries that imposed strong and smart containment measures earlier suffered less downward revisions to their fiscal balance and GDP growth projections. Fotiou and Lagerborg

[10] In our sample, the mean of the *phrt_smart* variable is around 34 days, and 1 st dev is around 54 days.

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(2021a) find that early and smart NPIs can lessen fiscal responses, although using different model specifications and definitions of stringency.

Table 1. Determinants of Total Fiscal Responses

VARIABLES	(1) Total	(2) Total	(3) Total	(4) Total	(5) Total	(6) Total
phrt_smart	0.016*	0.028**	0.046***			
	(0.008)	(0.011)	(0.012)			
avg_smart	-0.102*	-0.112*	-0.040			
	(0.057)	(0.063)	(0.045)			
phrt				0.016	0.020	0.031***
				(0.010)	(0.014)	(0.010)
avg				-0.097**	-0.093*	0.001
				(0.048)	(0.050)	(0.050)
lgdppc_rppp	2.948***	2.738***	-1.299	2.920***	2.852***	-0.619
	(0.426)	(0.761)	(0.840)	(0.404)	(0.746)	(1.005)
obsi2019		0.086***	0.052*		0.080**	0.044
		(0.029)	(0.031)		(0.030)	(0.037)
casespop		-0.853	1.017		-0.537	1.029
		(0.933)	(0.910)		(0.939)	(1.036)
lembi			-1.422**			-1.126
			(0.621)			(0.709)
Constant	-16.55***	-17.694***	22.042**	-16.07***	-18.725***	13.372
	(4.274)	(6.324)	(10.899)	(3.895)	(5.911)	(12.037)
Observations	147	105	56	147	105	56
R-squared	0.292	0.383	0.426	0.295	0.371	0.280

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Variable definitions: *phrt_smart* is PHRT measured using the OxCGRT containment and health index; *avg_smart* is the average OxCGRT containment and health index; *phrt* is PHRT measured using the OxCGRT stringency index; *avg* is the average OxCGRT stringency index; *lgdppc_rppp* is the (log of) GDP per capita in US dollar PPP terms; *obsi2019* is the 2019 OBS index measure of budget transparency; *casespop* is reported cases per population; *lembi* is the (log of) EMBI spreads.

Higher restrictiveness, on average, is not necessarily associated with lower fiscal responses. Estimated coefficients of *avg_smart* and *avg* variables are negative and statistically significant in only 5 of the 16 specifications (in tables 1, 2 and 3), including only once in the ATL health specification when including testing and contact tracing in the stringency definition (model 8). This could potentially be because the speed of introducing strict measures (*phrt_smart*) may contain the health and economic fallout earlier and as such lessen or nullify the need to maintain higher strict measures on average (*avg_smart*) over time. IMF (2020) reach a similar finding whereby early lockdowns, even if bearing short-term economic costs, may bring infections down faster and thus pave the way to a faster resumption of activity, possibly even leading to positive net effects on the economy. The simple average of statistically significant *avg* and *avg_smart* coefficients in tables 1-4 is around -0.08, indicating that a 10 percent increase in mean stringency is associated with a lower fiscal stimulus by 0.8 percent of GDP, holding all else constant.[11] Fotiou and Lagerborg (2021a) find similar, albeit weak, evidence. Balajee et al (2020), however, find that higher stringency, on average, is associated with more fiscal stimulus. This could be because their sample period ends in April which may have been rather short to capture the dynamics of stringency and fiscal reactions.

Fiscal space constrained the overall fiscal response. The estimated coefficient for EMBI spreads is negative as expected.[12] This is consistent with Balajee et al (2020) who find that lower credit ratings were associated with lower fiscal stimulus. The coefficient is statistically significant in the case of total fiscal response (table 1, model 3), but not other specifications. This could be because fiscal space was potentially not binding to the required health response (table 2), which was actually relatively higher in LIDCs –where fiscal space is most binding – both as a percent of GDP and as a share of total response. Fotiou and Lagerborg (2021a) also find that constrained access to finance was not a constraint in health spending. Similarly, fiscal space – although more limited in LIDCs and EMs than in AEs – may not have been a crucial factor in their BTL-CL response (table 3), given potential institutional constraints (see below) and their limited BTL-CL response overall. This suggests that fiscal space is potentially relevant to ATL non-health fiscal measures. We test this hypothesis in table 4 below.

Fiscal packages were larger for higher-income countries, especially BTL-CL measures, while lower-income countries spent more on health fiscal measures. As expected, higher fiscal responses are associated with higher GDP per capita. Balajee et al (2020) find similar evidence. However, this holds when using total (table 1) and BTL-CL fiscal measures (table 3) as the dependent variable. On the contrary, lower GDP per capita is associated with higher ATL health spending (table 2, models 8 and 11), as lower-income countries had weaker initial health infrastructure and preparedness overall going into the crisis, and as such had to spend relatively more on health measures in percent of GDP. Fotiou and Lagerborg (2021a) report similar results.

Health-related variables mattered for the health fiscal response. We find that the higher fiscal health response is associated with higher cases per population (table 2), but the relationship does not seem to hold in overall fiscal responses (table 1). Although not statistically significant, the GHS index is negative as expected (table 2), indicating that

[11] In our sample, the mean of the *avg_smart* variable is around 48 (index goes from 0-100), and 1 st dev is around 10. A 10 percent increase in the mean is thus equivalent to around ½ st dev.
[12] Specifications with EMBI spreads included as a control variable are, by definition, limited to a country sample of EMs and Frontier LIDCs. This issue is addressed in robustness checks in table 4.

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stronger health infrastructure is associated with less additional measures on health. Similarly, the coefficient on the share of population above 65 years of age is positive (table 2), although not statistically significant. Deb et al (2020a) use real-time data on COVID-19 confirmed cases and deaths and find that containment measures are more effective in countries with a relatively high share of elderly and those with a stronger GHS index. Aguirre and Hannan (2020) use state-level data from Mexico to show that age, pre-existing conditions and initial health capacity were important in controlling the fatality rate.

Table 2. Determinants of the Health Fiscal Response

VARIABLES	(7) ATL_health	(8) ATL _health	(9) ATL _health	(10) ATL _health	(11) ATL _health	(12) ATL _health
phrt_smart	0.002*	0.002*	0.002*			
	(0.001)	(0.001)	(0.001)			
avg_smart	-0.007	-0.010**	-0.012			
	(0.006)	(0.005)	(0.013)			
phrt				0.001	0.001	0.002
				(0.002)	(0.002)	(0.002)
avg				-0.003	-0.007	-0.004
				(0.006)	(0.006)	(0.011)
lgdppc_rppp	-0.039	-0.149**	-0.103	-0.037	-0.157*	-0.062
	(0.053)	(0.070)	(0.186)	(0.054)	(0.081)	(0.177)
GHSI	-0.002	-0.002	-0.005	-0.000	-0.002	-0.007
	(0.004)	(0.005)	(0.006)	(0.005)	(0.004)	(0.006)
casespop		0.236***	0.200**		0.245***	0.189**
		(0.065)	(0.078)		(0.052)	(0.080)
Popages65		0.013	0.010		0.013	0.014
		(0.012)	(0.027)		(0.013)	(0.026)
lembi			-0.052			-0.030
			(0.082)			(0.091)
Constant	1.364**	2.318***	2.369	1.159*	2.219***	1.599
	(0.594)	(0.541)	(1.785)	(0.612)	(0.767)	(1.687)
Observations	128	128	58	128	128	58
R-squared	0.045	0.140	0.152	0.015	0.117	0.112

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Variable definitions: *phrt_smart* is PHRT measured using the OxCGRT containment and health index; *avg_smart* is the average OxCGRT containment and health index; *phrt* is PHRT measured using the OxCGRT stringency index; *avg* is the average OxCGRT stringency index; *lgdppc_rppp* is the (log of) GDP per capita in US dollar PPP terms; *GHSI* is the GHS index measure of health infrastructure and preparedness; *casespop* is reported cases per population; *Popages65* is the share of population aged 65 years and above; *lembi* is the (log of) EMBI spreads.

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Higher budget transparency is associated with larger fiscal measures, especially BTL-CL measures. As expected, the estimated OBS index coefficient is positive and significant reflecting the importance of strong institutional and PFM capacity to respond with more BTL-CL measures (table 3, models 13 and 15). This also holds in the total fiscal response (table 1, models 2, 3 and 5), potentially because BTL-CL measures constituted the bulk of the overall fiscal response in AEs.

Table 3. Determinants of BTL and Contingent Liability (CL) Measures

VARIABLES	(13) BTL-CL	(14) BTL-CL	(15) BTL-CL	(16) BTL-CL
phrt_smart	0.028***	0.031**		
	(0.010)	(0.013)		
avg_smart	-0.062	-0.014		
	(0.047)	(0.042)		
phrt			0.027**	0.008
			(0.011)	(0.007)
avg			-0.053	0.024
			(0.039)	(0.043)
lgdppc_rppp		-0.109		0.454
		(0.473)		(0.695)
obsi2019	0.088***	0.024	0.086***	0.016
	(0.024)	(0.020)	(0.023)	(0.025)
lembi		-0.538		-0.411
		(0.405)		(0.533)
Constant	0.930	4.291	1.332	-2.400
	(2.220)	(5.721)	(1.851)	(7.953)
Observations	106	56	106	56
R-squared	0.179	0.305	0.163	0.121

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Variable definitions: *phrt_smart* is PHRT measured using the OxCGRT containment and health index; *avg_smart* is the average OxCGRT containment and health index; *phrt* is PHRT measured using the OxCGRT stringency index; *avg* is the average OxCGRT stringency index; *lgdppc_rppp* is the (log of) GDP per capita in US dollar PPP terms; *obsi2019* is the 2019 OBS index measure of budget transparency; *lembi* is the (log of) EMBI spreads.

The paper's main result on the role of fast and smart interventions holds under additional robustness checks (table 4). To further examine the robustness of the results, we use different measures of the dependent variable, namely ATL non-health (model 17) and total fiscal response including tax deferrals (model 18). Regarding independent variables, we first re-run the basic specification using a slightly different definition of PHRT (model 19). We also add revision to real GDP growth as a control variable to account for the impact of economic outlook (model 20), and experiment with alterative definitions of fiscal space (model 21). The paper's main result of a positive and significant *phrt_smart* coefficient continues to hold in all the specifications below. In all specifications, the *avg_smart* coefficient is insignificant, indicating that early strict interventions nullified the need to maintain high restrictions in average over time. Results (not shown) are mostly the same when using *phrt* and *avg* in place of *phrt_smart* and *avg_smart*.

In addition, we show that fiscal space mattered especially for ATL non-health measures and in developing countries, while worsening economic outlook mattered for the overall fiscal response. Specifically, robustness checks revealed the following additional results:

- **ATL non-health.** In this specification, the EMBI coefficient is negative and statistically significant, re-enforcing our view that fiscal space was binding especially for ATL non-health fiscal measures (model 17).
- **Tax deferrals.** Results on PHRT and EMBI spreads continue to hold when including tax deferrals as part of the overall fiscal response (model 18). In addition, stronger budget transparency is associated with a larger fiscal response.
- **Alternative PHRT definition.** Building on IMF (2020), we re-run the basic specification while defining PHRT as the number of days to reach maximum stringency after the 1st (not the 100th) case. Results (in model 19) hold. Further results (not shown) using *phrt* and *avg*, in place of *phrt_smart* and *avg_smart*, show that the relevant coefficient loses significance, re-enforcing the importance of smart, as opposed to only physical, containment measures.
- We control for the **revision to real GDP growth** by comparing growth rates from the IMF January 2020 WEO (before COVID-19) versus the October 2020 WEO (after COVID-19). This variable will have a negative value in most, if not all, countries.[13] The estimated coefficient is negative and significant suggesting that the worsening economic outlook prompted a larger overall fiscal response (model 20). This is in line with Fotiou and Lagerborg (2021a).
- **Alternative measures of fiscal space**. The baseline specifications use EMBI spreads as a summary measure of fiscal space. However, by definition, that leaves out AEs and most LIDCs. Alternatively, and building on Fotiou and Lagerborg (2021a), we use general government (GG) gross debt (in 2018), overall fiscal balance (average 2016-18) and a dummy for LIDCs. Results (in model 21) suggest that countries with higher debt (*GGdebt*) had larger fiscal packages. This potentially proxies for AEs capacity to carry debt. GG debt in developing countries (*GGdebtlidc*), however, constrained the fiscal response. Stronger initial fiscal balance positions (*GGfiscbal*) facilitated larger fiscal

[13] We expect the estimated coefficient to be negative in general implying that more downward GDP growth revisions were associated with a need for higher fiscal responses. That said, the causality could go in the other direction, where big fiscal responses could help smooth the revision in GDP growth rates, but we believe this to be minor as in general there would be a time lag between fiscal stimulus and the corresponding impact on economic activity.

stimulus in response to COVID. These results are in line with Fotiou and Lagerborg (2021a).

Table 4. Robustness Checks

VARIABLES	(17) ATL_ nonhealth	(18) Total_ deff	(19) Total	(20) Total	(21) Total
phrt_smart	0.011*	0.054***	0.056***	0.025**	0.018**
	(0.006)	(0.013)	(0.016)	(0.011)	(0.009)
avg_smart	-0.008	-0.009	-0.050	-0.016	-0.082
	(0.033)	(0.054)	(0.049)	(0.065)	(0.051)
lgdppc_rppp	-0.689	-0.860	-1.230	-0.153	2.901***
	(0.420)	(0.725)	(0.859)	(0.712)	(0.652)
obsi2019	0.016	0.054*	0.047		
	(0.014)	(0.032)	(0.034)		
casespop	1.013**		1.361		
	(0.413)		(0.975)		
lembi	-0.811***	-1.546**	-1.567**	-0.958*	
	(0.299)	(0.649)	(0.695)	(0.569)	
revggw				-0.249*	
				(0.148)	
GGdebt					0.085***
					(0.026)
GGdebtlidc					-0.082***
					(0.027)
GGfiscbal					0.306**
					(0.150)
lidc					5.683**
					(2.237)
Constant	11.999**	17.756*	20.815*	11.191	-21.690***
	(5.235)	(9.912)	(11.424)	(9.113)	(7.538)
Observations	52	56	56	60	143
R-squared	0.341	0.421	0.404	0.206	0.416

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Variable definitions: *phrt_smart* is PHRT measured using the OxCGRT containment and health index; *avg_smart* is the average OxCGRT containment and health index; *lgdppc_rppp* is the (log of) GDP per capita in US dollar PPP terms; *obsi2019* is the 2019 OBS index measure of budget transparency; *casespop* is reported cases per population; *lembi* is the (log of) EMBI spreads; *revggw* is the revision in GDP growth rates in Jan vs Oct 2020 WEO; *GGdebt* is General Government gross debt in 2018; *GGdebtlidc* is GG gross debt in LIDC countries only; *GGfiscbal* is GG overall fiscal balance average 2016-18; *lidc* is a dummy variable that takes the value of 1 for LIDCs and 0 otherwise.

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IV. Conclusion

The paper's main finding is that faster and smarter containment measures were associated with lower fiscal responses to COVID-19. The paper aims to study the determinants of countries' fiscal responses to COVID-19. This is done by regressing fiscal responses to COVID-19 (from the IMF Fiscal Monitor Database) on a measure of the speed of adopting strict containment measures (the public health response time), the degree of stringency measures (average OxCGRT stringency index from Jan 1st to October 15th), while controlling for other variables and initial conditions that may affect fiscal responses such as fiscal space, income, and health infrastructure among others. In measuring PHRT and average stringency, we differentiate between physical containment measures (such as lockdowns and travel restrictions) and smart containment measures (such as testing policies and contact tracing). The paper's main result – that faster and smarter containment measures were associated with lower fiscal measures in response to COVID-19 – is robust to different specifications including alternative measures of the dependent and independent variables. The empirical methodology is subject to a number of caveats, importantly the endogeneity of many variables and as such regression results presented show associations not causation.

Other results highlight that initial conditions shaped the amount and design of the COVID-19 fiscal response. We find that fiscal space constrained the overall fiscal response, especially in non-health fiscal measures and in developing countries. We also find that fiscal packages, especially below-the-line measures, were larger for higher-income countries, while lower-income countries spent more on health given their weaker initial health infrastructure and preparedness. Other health-related variables, such as cases per population and the share of elderly population, mattered for the health fiscal response. Higher budget transparency was also found to be associated with a larger fiscal response, reflecting the importance of strong institutional and PFM capacity. Results are robust to different specifications.

This paper's findings suggest that in the efforts to minimize health and economic losses, smart and rapid containment measures are essential. This is an important message for policymakers. Observational and empirical evidence in the literature suggest that quick and smart interventions may better and faster contain the spread of infections. Empirical evidence in this paper further suggest that the same quick and smart containment measures can also reduce the size of the fiscal response to the COVID-19 shock. This suggests that the same measures that help save lives, can also save fiscal resources.

Our results motivate future research in several aspects. Econometric improvements could include, first, a re-examination of the determinants of fiscal response to COVID-19 in a panel context, once time series data on countries' fiscal responses become available. Second, and contingent on having panel observations, an instrumental variable approach may be used to

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address potential endogeneity problems. Comparative country case studies could also be useful to help understand how countries used their fiscal space during the pandemic, including on the effectiveness and efficiency of the adopted fiscal measures.

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Couples in lockdown, "La vie en rose"? Evidence from France[1]

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Stay-at-home policies due to the Covid-19 pandemic have drastically increased housework and childcare. During the lockdown, couples were harshly challenged by this novel situation which could notably redistribute roles and/or could also lead to intrahousehold conflicts. In this paper, we use individual data collected from an online survey on French partnered women during the confinement of the 2020 Spring to investigate the lockdown's effects on the household chores allocation and tensions in the couple. We show that the lockdown did not offer an opportunity to strongly renegotiate the housework and childcare division between the partners, as women still did the lion's share during this period. Men changed their participation in household chores that are quasi-leisure, such as shopping and playing with children. We also document that an unbalanced division of the increased household chores during the lockdown, in particular on cleaning and childcare, is directly linked to an increase of the intrahousehold conflicts. To conclude, this period did not structurally affect gender roles and stereotypes at home, despite minor intrahousehold changes.

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1 Introduction

In France and all over the world where stay-at-home policies were implemented, the first lockdown of the Spring 2020 harshly affected and challenged partners in their households. The effects of this sudden forced coexistence impacted the household on the amount of housework and childcare (Farré et al., 2020; Del Boca et al., 2020), the occurrence of domestic tensions (Biroli et al., 2020) or even intimate partner violence (Arenas-Arroyo et al., 2020; Beland et al., 2020; Morgan and Boxall, 2020; Ravindran and Shah, 2020; Hsu and Henke, 2020). Witnesses of the domestic violence, the helplines also knew a dramatic rise of the distress calls in western countries (Leslie and Wilson, 2020; Bullinger et al., 2020; Miller et al., 2020) as well as in developing countries (Agüero, 2020; Perez-Vincent and Carreras, 2020). For France, we notice a rise by 44% of police interventions for family disputes while the calls to the helplines for domestic violence doubled.[1] Futhermore, 49% of the french couples reported intrahousehold conflicts due to the housework distribution during the lockdown, and one-third of the women who reported these frequent disputes suffered from verbal abuse.[2] From the 2020 Insee report on family and social inequality, we also note that 13% of the french couples (16% of the parents) reported more frequent disputes during the lockdown while women continued to do the lion's share of the housework (Barhoumi et al., 2020).

In this paper, we aim to investigate the link between household tasks distribution and intrahousehold conflict, addressing two intertwined research questions. (i) Has the lockdown induced a (re)distribution of household chores between the two partners? If yes, do men increase their participation in tasks that are perceived to have a female connotation? (ii) Does a more equal burden sharing reduce the likelihood that a woman reports that a conflict has occurred? Is there a relationship between the type of the task in which men participate and the incidence of conflicts? As the stay-at-home policies did not homogeneously affect workers, we explore the heterogeneities in the results according to the confinement status of the couple.[3]

We use original data, own-collected via an on-line survey between April 21 and May 10, 2020 on 2,907 partnered women.[4] The survey collected fine-grained information on the housework and childcare contribution of the two partners as well as on the occurrence of conflicts in the couple before and during the lockdown.[5] We show that only couples with kids where both partners stayed at home or where the woman was working

[1]This information comes from France Inter's website, "Violences faites aux femmes : que s'est-il vraiment passé pendant le confinement ?", published on May 15 2020.

[2]These data are from an Ifop's survey "Enquête sur les conditions de logement des Français confinés et les tensions au sein des foyers" on a representative sample of 3 011 respondents, published on April 7 2020. Ifop also provided a similar study in 2019, where 45% of the french couples reported conflicts due to the division of the housework.

[3]Four types of confinement status are defined during the lockdown: (1) when both partners were confined at home, it is the basic situation in the stay-at-home policies; (2) when the woman was the only to work outside; (3) when the man was the only to work outside; (4) when both partners worked outside. Being an "essential worker" was a reason why some people continue to commute to their workplace in this period, as for instance in the construction industry, in supermarkets or in personal care services.

[4]The French president Emmanuel Macron announced the closure of kinder-gardens, schools and universities for an unspecified time in the speech he delivered on March 12, 2020, and he then imposed the total lockdown on March 16, 2020; going out of home was limited to essential tasks, such as food shopping and working (in cases in which working from home was unfeasible), plus the opportunity to walk or doing physical activities for at most one hour per day within a one kilometer radius from home.

[5]In the paper, we alternative name household tasks, household activities or household chores to indicate both housework (i.e. cleaning, laundry, shopping and cooking) and childcare (i.e. homework and playing).

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outside during the lockdown significantly reduced the gender gap in both housework and childcare. Interestingly, for the totally confined parents, this change is particularly driven by the male participation in shopping and in playing with kids, the less female-connoted activities considered in this study. These two tasks could also be considered as a quasi-leisure in period of lockdown. This result claims the null-effect or, at most, the feeble impact of the lockdown on the household chores distribution. For most of the confinement statuses, we also find that conflictual situations arised when the gender gap of the household chores distribution increased during the lockdown. This result means that redistributing the burden of household tasks during the lockdown is likely to limit the disputes between partners. We notably document that the tensions mostly appeared when the gender imbalance increased in cleaning, the most time consuming and female-connoted household chore.

Our paper first contributes to the literature on the gendered division of household chores, and in particular to the relationship between gender preferences and the within-couple variation of household tasks allocation over time. The asymmetric allocation of the housework between partners has been largely lighted by seminal theoretical papers as in Becker (1965) or in Gronau (1977). Despite a large reduction of the gender gap in the labor market, women continue to do the lion's share of the housework (see the recent literature review by Lachance-Grzela and Bouchard (2010)), even if researchers notice that the division of the housework became more balanced and the gender gap converges over the life span (Lam et al., 2012; Leopold et al., 2018). Exploiting changes in the labor market participation in the couple, some authors document some within-couple variation of the housework division. Killewald and Gough (2010) and Foster and Stratton (2018) show that the new-unemployed men increase the share of housework, but to just around half of the time devoted by women to them. Álvarez and Miles-Touya (2019) exploit a specific feature of the Spanish Time Use Survey to provide the evidence that men increase their contribution to housework in their non-working days, but to a lesser extent than women. Therefore, many unobservables factors as the social norms, stereotypes or preferences remain and are shaping the constant gender gap across cohorts. Using an experiment, Couprie et al. (2020) investigate the influence of the stereotypes and find that partners overspecialize their housework in accordance with their gender roles. As observed by Kahneman et al. (2004), household chores also differ in terms of pleasantness and physical effort. If Auspurg et al. (2017) do not find any little evidence of any systematic gender differences in preferences, Stratton (2012) show that men's preferences drive their commitment in housework.[6] In this paper, we claim that men contribute more to chores that became a "quasi-leisure" in the lockdown period, showing that the gendered nature of a task seems to respond to its changing attractiveness rather than being a stable feature. This finding illustrates a possible change of men's preferences due to the constraints during the pandemic, modifying the division of the housework.

We also relate to the literature analyzing how the occurrence of conflicts within the couple is linked to the allocation of tasks between partners. The economic and sociological literature has addressed the question

[6]To our knowledge, the (economic) literature exploring heterogeneity of preferences for type of housework activities among partners is limited. Van der Lippe et al. (2013) suggest that gender preferences for housework matters for outsourcing. More interestingly, Van Berkel and De Graaf (1999) show that cooking and shopping are considered as enjoyable housework activities by men and women, while cleaning is disliked by both partners. This is in line with the work by Shaw (1988), who indicated that cooking was among the preferred housework tasks. Empirical work on housework, often uses the distinction between "female-typed housework", that includes laundry, housecleaning, washing dishes, and cooking and "total housework". Shopping is included in the second category, together with gardening, pets care and other tasks that can be considered as semi-leisure (Kahneman et al., 2004)

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whether the men's participation in household activities stabilizes marriage and reduces the risk of separation. According to the Becker's theory of specialization, we could expect the separation risk to decrease with partner's specialization because the partners' mutual dependence increases, e.g. women take care of household chores, men taking the role of breadwinner (Becker, 1981, 1985; Cooke, 2006). On the other hand, the separation risk could increase because of the dissatisfaction of the women who have to carry most of the burden at home. The risk could be higher for the couples where the woman has more bargaining power, because of her high education level or her high part of the total family income. Cooke (2006), Sigle-Rushton (2010) or Ruppanner et al. (2018) empirically show that the risk of separation is lower in couples where the man is more involved in housework (and childcare, where there are children). Conversely, Norman et al. (2018) found that father's involvement in childcare in the first year after the birth is associated with couple stability, but this is not always the case for his involvement in other tasks. According to Altintas and Sullivan (2016) and Van der Lippe et al. (2014), frictions about the allocation of the housework among partners is one of the main sources of marital conflict.[7] In the context of the Covid19 pandemic, Beland et al. (2020), Biroli et al. (2020) and Hsu and Henke (2020) have documented an increase, respectively, in domestic violence and family tensions during the lockdown. This paper is directly linked to this literature, showing that an increase in the unbalanced division of the housework during a stressful situation as the lockdown rise the likelihood of conflicts among partners.

Finally, we contribute to the emerging literature on the effects of the stay-at-home policies during the Covid-19 pandemic, and notably the multifaceted implications of the lockdown on couples and households. Several papers have documented the quantitative increase of hours allocated to the household chores and childcare, and the change of couples' behaviour. For Spain, Farré et al. (2020) show an slight increase in the male partner's share of housework and childcare, but also that women still take the lion's share.[8] In Italy, Del Boca et al. (2020) find that men increase the time they spend in gratifying tasks, as children related activities, rather than the time doing chores. Using data from England, Andrew et al. (2020) show that during the lockdown mother spent more time in housework and childcare than their partners. Using panel data on German families, Hank and Steinbach (2020) document that there is no fundamental changes in established patterns of couples' division of labor during the lockdown. In Italy and the US, Biroli et al. (2020) document that families experienced an increase of intra-household tensions, even if men increased their share of childcare and grocery shopping duties. To the best of our knowledge, our paper is the first exploring the link between the household chores division and the occurrence of conflicts between partners at the confinement period. Moreover, the issues related to family, couples and household during the pandemic still remain overlooked in the literature for France.

The rest of the paper is structured as follows: Section 2 describes our original dataset. The effect of the lockdown on the division of the housework and childcare related activities are presented in Section 3. We discuss the relationship between tasks distribution and the occurrence of the conflicts in Section 4. Section

[7]Related to this, some evidence exists on a negative association between the psychological distress and a more equal distribution of housework among partners (Lennon and Rosenfield, 1994; Kalmijn and Monden, 2012; Harryson et al., 2012). Carlson et al. (2016) show that a more egalitarian division of housework matters for sexual relations.

[8]Our data are particularly close to their dataset, who also have information on the time spent by respondents and partners on each type of task. They also showed that the increase in men's contribution to housework was mostly concentrated on the shopping activity.

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5 concludes.

2 EICM Survey and Data

In order to investigate specific issues on the changes due to the pandemic and the lockdown in France, we conducted a real time survey using an on-line software from April 21 to May 10 2020.[9] The survey was spread using different ways: (i) through the personal and professional networks of the authors, (ii) through a mass-emailing strategy that targeted metropolitan French kindergartens and primary schools and (iii) through a 5 days marketing campaign on Facebook and Twitter. Using social networks allowed us to increase our audience and balance our sample as they have randomly distributed the survey among the targeted population. The raw dataset was collected on 4,616 individuals under the name of *Enquête sur l'Impact Economique et social du COVID-19 sur les Ménages*(EICM). Although we did not explicitly target them in the distribution of the survey, most of our respondents were women.

This might be explained by the fact that women felt more concerned by the topics raised by the survey. The low number of male respondents prevents us to study the male perceptions on the intra-household relationships. Therefore, we only restrict our sample on the partnered women respondents with fully information since we are interested on intra-household relationships in this paper. We finally rely on a sample of 2,844 women, reporting basic information including location, education, civil status and working status before and during the lockdown. Each respondent reports the same information for her partner. The survey also provides information on the division of housework and childcare tasks before and during the lockdown.

As respondent intentionally participated to our survey and the data were not collected using a sampling design, our dataset is not representative of French women population. Table A1 reports comparisons between EICM dataset and INSEE data. Thanks to the great efforts in the distribution of the questionnaire, we observe that our sample is relatively well balanced at geographical level, except for an over-representation of women from AURA region and an under-representation of women from Ile de France region.[10]

We also find that our sample under-represents women without an university degree (59.85% in EICM compared to 75.4% in INSEE data). This selection bias could also be linked to the author's networks and the individual's preferences who lead the interest to participate at this survey. We thus weighted our estimates in order to correct for the under representativeness of lower educated women.[11]

Table A2 presents the descriptive statistics on the outcome variables and on the covariates for the sample of women, both before and during the lockdown. More details on the described variables are given in the next sections.

[9] A first version of the survey was developed by Lidia Farré (Universitat de Barcelona) and Libertad Gonzales (Universitat Pompeu Fabra) with the aim of collecting early data on the labor market consequences as well as the intrahousehold relationships during the lockdown. Similar surveys were then spread in France, Italy, Germany and Austria. The French and the Italian versions included detailed questions on children time use, when respondents lived with their kids. The French version also added some questions on the conflicts between partners during the lockdown. The questionnaire is available from the authors upon request.

[10] The high number of respondents from the AURA region can be explained by the residence location of the authors, who spread in their own networks the survey.

[11] All of our results remain stable when we do not reweight the estimates. These results are available from the authors upon request.

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3 Intrahousehold division of the household chores during the lock-down

3.1 Time-use and division of household chores

This section explores the changes in the partners' contribution to housework and childcare activities during the Spring 2020 lockdown in France. The EICM survey collected information on all domestic chores and children related activities shared by the partners in the daily life. We focus on the main household chores (i.e. cleaning, cooking, laundry and shopping) and on two activities related to kids, helping with homework and playing.

Figure 1 graphically presents average hours spent in household tasks for women with and without children for the periods before and during the pandemic.[12] Unsurprisingly, the reported time spent in household chores was more important for women with children at home than for women without, both before and during lock-down. During the lockdown, we find a similar increase in the number of hours consecrated to the housework for the two groups of women. Moreover, the time spent by mothers in the educational activities with their kids considerably increased during the lockdown, from an average of 2 to more than 8 hours per week.

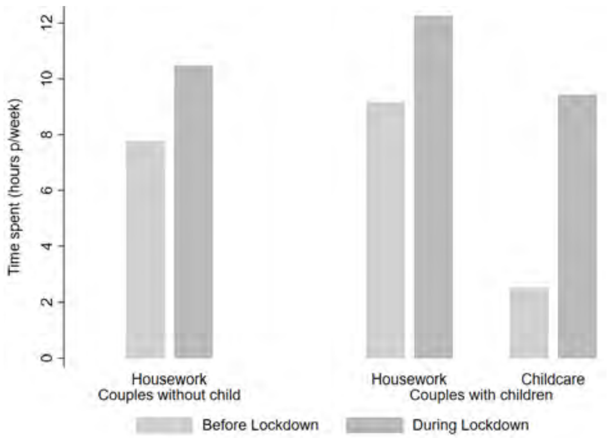

Figure 1: Time spent by women into household tasks

Respondents also reported the division of time between partners for each household chore before and during the lockdown. We draw this information using a Likert scale on woman participation in household chores, from which we created an index for the women's share of household chores.[13] This index is obtained by

[12]We asked women the total number of weekly hours they devoted before and during the lockdown to the three following chores: cleaning, cooking and laundry. The time spent on shopping was not asked here because this activity can be reasonably assumed to be constant across the two periods. Using the *Enquête Emploi du Temps* from INSEE in 2010, we also find that this activity counts for less than 15% of the total of time spent in the major housework activities mentioned in our survey.

[13]For each task, we asked the question "Who is doing the activity in the considered period ?". Respondents had the following choices: "always me"; "me most of the time"; "my partner and me equally"; "my partner most of the time"; "always my

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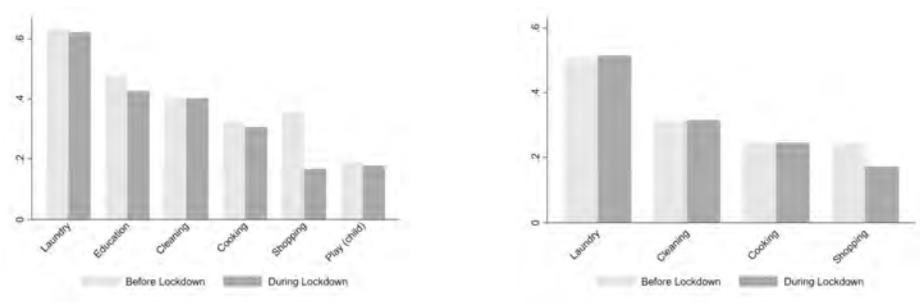
computing the mean of women participation in all tasks and ranges between 0 and 1. Correspondingly, we defined the men's share as the reversed women's involvement, i.e. 1 minus the women's share.
Using the kernel density of this index of the housework division between the partners, we show that, on average, couples with children experience a more unequal household tasks' distribution (Figure A1). We also note that the two types of couples do not diverge in terms of distribution of the index for the situations where male partner assume most of the housework burden.

Figure 2 shows for each task the gender gap in the division of the housework.[14] First of all, we notice that women continue to do the lion's share of the housework even during the pandemic as the tasks gap between partners remains positive. This finding is consistent with national data provided from the French national statistics institute, Insee, in Barhoumi et al. (2020). Second, we also observe that gender gaps before the lockdown are systematically higher for couples with children, indicating that the additional burden due to the presence of kids is mostly taken by women. Couples with children knew on average a strong reduction of the gap in shopping activities, while fathers also increased their participation in all activities except cleaning. Conversely in couples without children, men did not rise their share for most of the tasks, except for shopping which presents the highest redistribution. This is similar to results found in the literature by Mangiavacchi et al. (2020) in Italy and by Farré et al. (2020) in Spain, where the gender gap on shopping became negative during the lockdown.



(a) With children

(b) Without children

Figure 2: Evolution of tasks gap between partners into the household

The lockdown in France was accompanied by government statements promoting teleworking when it was possible. We consequently differentiate in our survey four types of confinement status for couples: those where both partners worked outside during lock-down (1), those where only one out of the two partners worked outside, either the woman (2) or the man (3), and couples where both partners stayed at home (4). Figure 3 illustrates the evolution of the gender gap in housework and childcare across the four groups, computed on both couples with and without kids (except for children related activities). We observe a

partner"; "another person". We attribute the values 1, 0.75, 0.5, 0.25 and 0 respectively to the first five previous options. Only a minority of respondents replied that another person took care of some tasks before the lockdown (less than 1%, except for the cleaning who was carried out by 4.4% by another person), while during the lockdown, all tasks were assumed at 99% by the respondent or partner. We attribute the value of 0.5 in the case where another person was doing the task.

[14] We computed the gender gap as the difference between the women's share and the men's share. When the gender gap is zero, the task is equally distributed among partners, while a negative gap means that men take care for most of the burden.

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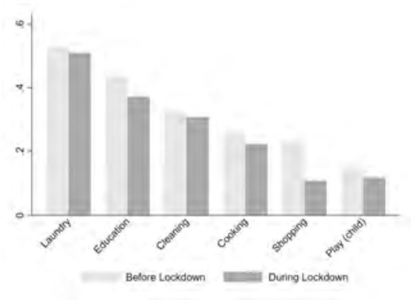
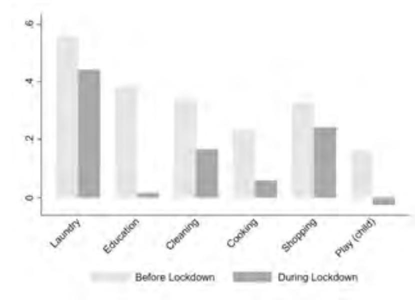
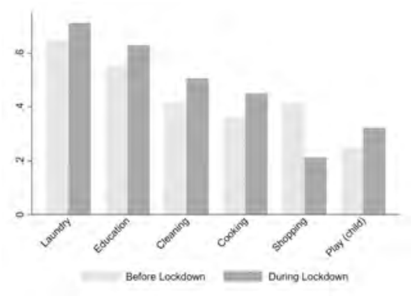
higher reduction in the gender gap when the woman only worked outside during the lockdown. Conversely, when men was the only one who worked outside, we observe an increase in the gender gap for all activities, except for shopping. Descriptives also indicate a very low reduction in the gender gap when both partners were working outside and when both were at home. These findings denote the high heterogeneity in the intrahousehold division of housework and childcare due to the confinement status of the partners.



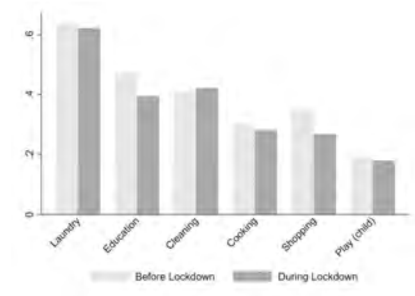
(a) Both at home



(b) Woman outside



(c) Man outside



(d) Both outside

Figure 3: Evolution of tasks gap between partners into the household

We also explored the heterogeneity of the gender gap reduction across women education level. Our result indicates that the gender gap in housework and childcare before the lockdown is lower in couples for which woman has an education level above high school diploma.[15] During the lockdown, we observe an higher reduction of this gap on education activities with kids for women having an university degree, while there is no other difference across women's level of education for the other tasks.

3.2 Model and results

Model

In this section, we question if the lockdown challenged the intrahousehold equilibrium of the couple. Our specification applies a basic panel fixed effects model with two time periods, before and during the pandemic, estimated as following:

[15]We do not present the figures for this heterogeneity in this paper. Descriptives are available from the authors upon request.

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$$Share_{its} = \theta_0 Lockdown_t + \theta_s Lockdown_t \times Status_s + \gamma X_{it} + u_i + \epsilon_{its} \quad (1)$$

Here, we denote with $Share_{it}$ the share of the housework done by the woman i in the period t and in the confinement status s. As described in the Section 3.1, our outcome is the simple average of the women's shares on each domestic task. We obtain a global index for the housework distribution taking values from 0 when all tasks were made by the partner to 1 when all tasks were made by the woman. This outcome does not include childcare related activities. For couples with kids, we also use an alternative outcome which computes both the average shares of the childcare and the housework done by the women.

As variables of interest, we simultaneously use the temporal dummy, called $Lockdown_t$, equal to 1 when the period is the lockdown, and its interactions with the different confinement status of the couple $Status_s$. Dummies related to the three couple situations for which one partner is working outside during the pandemic, $Status_s$, are described in the previous Section 3.1. The coefficient θ_0 consequently captures the effect of the lockdown on the tasks distribution when both partners stayed at home and θ_s are coefficients capturing the conditional effect to each s situation: (1) when the woman was working outside, (2) when the man was working outside, (3) when both partners were working outside. Therefore, we need to interpret total effects as $\theta_0 + \theta_s$ for each s situation. We also control for the labor market participation of the respondent and her partner: vector X includes a dummy equal to one if the respondent is working at the considered period and a similar dummy for her partner. These time-variant covariates allow us to take into account the change in the labor market which was heavily affected during the pandemic. u_i captures time-invariant characteristics for each respondent and household. ϵ_{its} is the error term.

Results

Main results are presented in Table 1. Column 1 presents the results of the specification in Eq. 1 on the full sample of respondents. These first results show that the effects of the lockdown on the housework sharing are heterogeneous across the confinement status. We add in column 2 an interactive term between the lockdown variable and a dummy equal to one for couples with kids. The coefficient in front of this interactive term is significant and positive, meaning that the effects for couples where both partners stay home (i.e. the reference category) are different according to the parent status. We consequently provide subsample analysis on couples without and with kids at home during the lockdown. These estimates are shown in column 3 and column 4, respectively.

These subsample analysis are graphically presented in the Figure 4, where we draw point estimates, 90% and 95% confidence intervals, as well as the sample distribution allocated for each confinement situation.[16] For couples having kids at home, we find that there is a more equal division of the housework during the lockdown when both partners stayed at home. When the woman was the sole working outside the home, we find that the redistribution is stronger in her favour. On the other hand, when the man was the only one to work outside or when both partners worked outside, there is any significant change of the housework division during the pandemic. For couples without kids, we find that the distribution of the housework during the lockdown has not significantly changed, regardless of the confinement status.

[16] Although we present the 90% confidence intervals in the Figure 4 and in the following figures, we consider results as strictly significant only for coefficients with a pvalue lower than 0.05.

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Using as outcome an index based on both housework and childcare related activities, we estimate the Eq. 1 and present the result in the column 5 of the Table 1 for the couples with children. Effects are also graphically presented in Appendix, Figure A2. Our results remain stable to the inclusion of the childcare division in the outcome for most of the cases, except for the case where both partners worked outside during the lockdown which becomes significant.

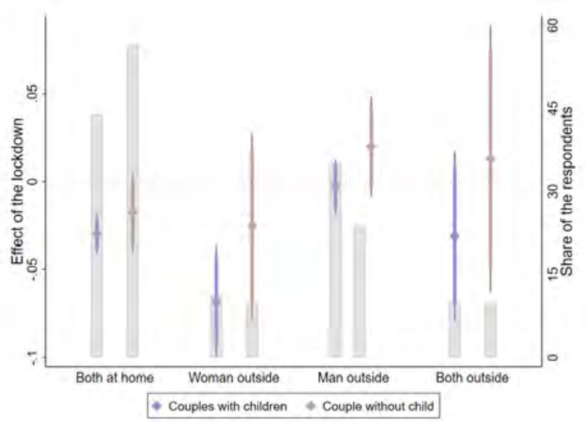

Figure 4: Effects of the lockdown on the housework division

Note: This figure presents the effects of the lockdown on the housework division between partners on subsamples of couples without and with children. Marginal effects of the lockdown are directly computed from the coefficients presented in the Table 1, columns 3 and 4, setting for different values of $Status_s$, confinement status of the couple, *i.e.* "both at home" ; "woman outside" ; "man outside" ; "both outside". The left axis reports marginal effects values and the right axis reports the distribution of the confinement status among the subsample population.

In order to disentangle if the results presented above are driven by some of the task we included in our composite index, we re-estimate Eq. 1 using the share of work done by women in each activity as outcome. Results for couples with and without kids are graphically illustrated in Figure 5. We find that for couples with kids where both partners were at home, the redistribution effect is only led by shopping and playing with kids. For the other activities, we observe a statu quo in the distribution of the task. When the woman is the sole household member working out of home, the man's contribution increases in all activities, except for shopping. This is the situation for which the redistribution is really effective between the partners. While we found a global no-effect when men worked outside during the lockdown, we note that they significantly reduced their participation in the main domestic tasks as cleaning, cooking or laundry as well as in childcare, while they only raised their contribution in shopping. When both partners worked outside, we only find a redistribution in favour of women in doing homework with kids. [17]

For couples without kids, although the global housework index was non-significant, we observe a reduction in the woman's contribution in shopping activity for confined couples, even if this decrease is narrower

[17] This result explains why we find a significant effect of lockdown on the share only when we include childcare in the index for couples where both partners worked outside.

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Table 1: Lockdown and household chores division between partners

	Full sample		No Children	With Children	
	(1)[a]	(2)[a]	(3)[a]	(4)[a]	(5)[b]
Lockdown	-0.0225***	-0.0120	-0.0177	-0.0297***	-0.0294**
	(0.00625)	(0.00785)	(0.0103)	(0.00520)	(0.0102)
Children (=1) × Lockdown		-0.0236**			
		(0.00884)			
Woman outside × Lockdown	-0.0272**	-0.0252**	-0.00767	-0.0384**	-0.0869***
	(0.0114)	(0.0113)	(0.0229)	(0.0154)	(0.0210)
Partner outside × Lockdown	0.0265***	0.0319***	0.0378*	0.0266***	0.0597***
	(0.00809)	(0.00902)	(0.0182)	(0.00742)	(0.0109)
Both outside × Lockdown	0.00399	0.00785	0.000531	0.0105	0.00560
	(0.00901)	(0.00936)	(0.0137)	(0.0120)	(0.0244)
Work (Woman)	-0.0296*	-0.0296*	-0.0405**	-0.0213	-0.0464**
	(0.0148)	(0.0149)	(0.0171)	(0.0174)	(0.0164)
Work (Man)	0.0533***	0.0497***	0.0434**	0.0539***	0.0340**
	(0.00933)	(0.00907)	(0.0190)	(0.00904)	(0.0146)
Observations	5,688	5,688	2,458	3,230	3,230
R-squared	0.860	0.861	0.873	0.851	0.838
Labor market controls	Yes	Yes	Yes	Yes	Yes
Individual fixed effects	Yes	Yes	Yes	Yes	Yes

All results were estimated using fixed effects model based on panel data from EICM online survey collected in France from April 21 to 10 May 2020. Sample selection retains only partnered women respondents. Lockdown is a variable equal to one for confinement period. Children is a dummy equal to one if the couples lived with at least a child during the lockdown. Columns 1 to 2 present results on the full sample selection. Column 3 focus on couples without children. Columns 4 to 5 present results on the subsample of couples with at least one child.

All specifications use the covariates of the Eq. 1. We include the $Status_s$ referring to the confinement status of the members of the household as presented in Section 3.1. $Status_s$ are interacted with $Lockdown_t$ and presented according to the label of the category. The category of reference is when both partners stayed at home during the lockdown. Other covariates are related to the women and partners' labor market participation (here, Work (Woman) and Work (Man)).

[a] : these estimates use as outcome the housework division, $Share_{it}$, as presented in the Eq. 1.

[b] : this estimate uses as outcome a combined index using the average share of the childcare and the housework done by the woman.

Each estimates controls for individual fixed effects. Standard Errors in parentheses are clustered at regional level. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively.

than for couples with kids in the same situation. Interestingly, we also observe that women do more in the laundry activity when men worked outside during the pandemic. Other results for couples without kids are non-significant.

We can conclude that on average the lockdown did not lead to a large change in the intrahousehold division

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of the domestic chores. Changes are concentrated almost exclusively on couples with kids with at least one of the two partners being confined at home during the lockdown. In those situations where only one of two parents was working outside, the other was logically raising its contribution. Furthermore, for the shopping, the households rationally promoted the partner who was already out of the dwelling for working as in charge of this activity. The global effect of the households chores redistribution for couples who stayed at home during the pandemic is mainly due to the increase of men's participation in shopping and on a less extent to the increase of fathers' contribution in playing with kids activity. The effect found on shopping could be symptomatic of a circumstantial intrahousehold change rather than a structural one. This change can be explained with two alternative or complementary hypotheses. First, shopping could have been considered as a risky activity due to the pandemic, and men could have assumed their traditional role of 'protector' of the family, taking the risk upon themselves. In this scenario, shopping was likely to became a male-connoted task and partners conform to social gender roles (Couprie et al., 2020). A second explanation relates to the specific nature of shopping during the confinement. In a situation in which individuals had to stay at home and were only allowed to go out for essential tasks, shopping became an interesting activity (especially for those people working from home). Going to shopping might represent for them an escape from the forced cohabitation and can be seen as a kind of leisure. Remark that shopping is an activity that is traditionally carried out by women (before the lockdown, the women's share for shopping was on average at 67 per cent). The increase in the involvement of men in shopping during the lockdown suggests that the gendered nature of a task seems to respond to its (changing) attractiveness rather being a stable, essential feature of the task. Compared to the other tasks, shopping is also well identified by other household members during the lockdown and could help the protagonist to bargain his lower involvement in other housework.

4 Intrahousehold conflicts occurrence and household chores division

In this section, we investigate the link between the share of household chores realized by women and the occurrence of the conflicts among partners.

4.1 The conflict measure

In the survey, each sampled woman reported if she has experienced more or less conflictual situations with her partner during the lockdown compared to the usual time. Figure 6 shows the proportion of women (with and without children) who declared having experienced more or fewer conflicts during the lockdown compared to the previous period. If most of the respondents did not declare any change, 28% of respondents with kids and 22% without kids reported an increase of the occurrence of conflict. Interestingly, this divergence between the types of couples is complying with data from the Insee's report about the French family during the lockdown, where couples with children are more likely to report disputes between partners (Barhoumi et al., 2020). For couples with children, the proportion of respondents declaring more conflict is slightly higher when the two adults stayed at home during the lockdown, or when the woman was the sole outside worker. For the couples without children, the share of women reporting more conflict is slightly lower when

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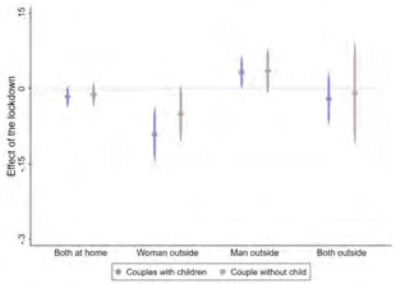
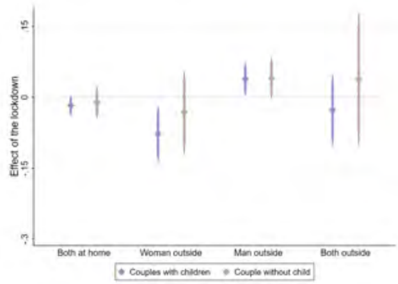
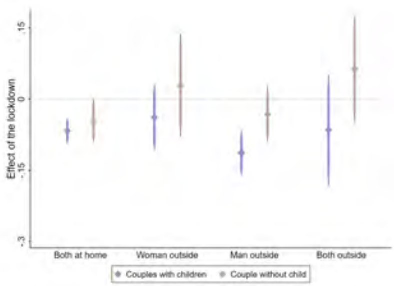


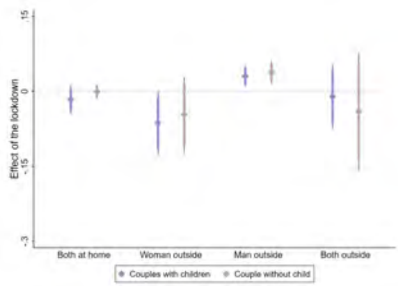
(a) Activity: Cleaning the household



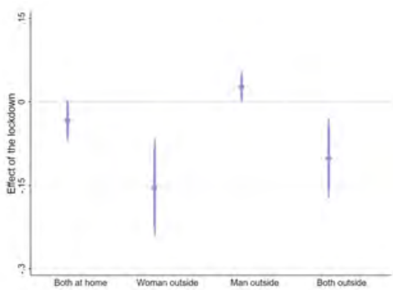
(b) Activity: Cooking



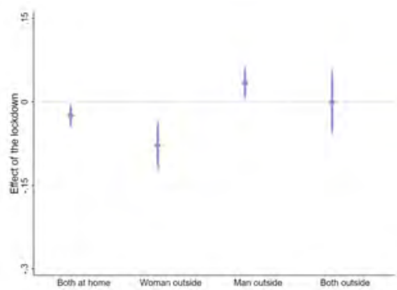
(c) Activity: Shopping



(d) Activity: Laundry



(e) Activity: Homework with children



(f) Activity: Playing with children

Figure 5: Effects of the lockdown on the household chores division

Note: These figures present the effects of the lockdown on the division between partners of each household chore on subsamples of couples without and with children. Marginal effects of the lockdown are directly computed from the estimated coefficients of the Eq. 1 using as dependent variable the share done by woman in each activity and setting for different values of $Status_s$, confinement status of the couple, *i.e.* "both at home" ; "woman outside" ; "man outside" ; "both outside".

both individuals were working outside with regard to the other situations.[18]

[18] Investigating other dimensions which could led to an increase of conflict, descriptives do not show that income inequality increases or decreases the occurrence of conflict.

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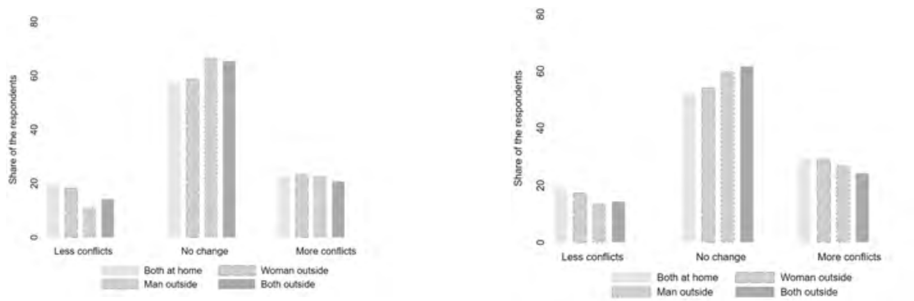

(a) Without children

(b) With children

Figure 6: Occurence of the conflicts into the households

In what follows, we investigate the effect of the lockdown on the conflict occurrence among partners as well as the relationship between conflicts and household chores division in confinement. More specifically, we wonder if the limited increase in the male participation into the household chores illustrated in the previous section reduced the likelihood of conflict occurrence in the couple.

4.2 Model and results

Model

In order to capture the effects of the lockdown and of the sharing of household tasks on conflict occurrence, we use as dependent variable $Conflict_{it}$ a dummy that take the value of one when the woman i experiences a more conflictual relationship with her partner at time t. Thus the dummy is equal to 1 at time t_0, before the lockdown, if the couple's relationship improved during the lockdown, and zero otherwise. Symmetrically, the outcome is equal to 1 at time t_1 if the relationship worsened, and zero otherwise. For a couple that did not experience any change, the dummy is equal to 0 for both periods t_0 and t_1.

We estimate a basic fixed effects model, as:

$$Conflict_{it} = \theta Lockdown_t + \alpha Share_{it} + \beta Share_{it} \cdot Lockdown_t + \theta_s Lockdown_t \times Status_s + \gamma X_{it} + u_i + \epsilon_{it} \quad (2)$$

where $Share_{it}$ denotes our main variable of interest, representing the average share of household chores done by the woman. More specifically, as in Section 3.2, we use two different indicators for $Share_{it}$: (i) the woman's share of housework and (ii) a composite indicator combining both housework and childcare activities.

Interacting this variable with $Lockdown_t$ allows us to capture the specific effect of the woman's share of tasks during the lockdown. As in Eq. 1, we control for the specific role played by the confinement status of the couple, interacting $Status_s$ with $Lockdown_t$. X_{it} is a vector of covariates that includes the employment status of the respondent and her partner before and during the pandemic. u_i captures time-invariant characteristics for each respondent and household. ϵ_{it} is the error term.

Results

We report results in Table 2. Column 1 first presents a parsimonious specification with *Lockdown* and its interactions with $Status_s$ as sole variables of interest and X as other covariates for the full sample of respondents, i.e. for couples with and without children. From this result, we find that in average the occurrence of conflicts increased during the lockdown. In column 2, the specification adds the $Share_{it}$ variable and its interaction with the lockdown, on the full sample as well. Column (3) reports the results for the same model for couples without kids only, while column (4) for couples with kids only. Finally, the last column reports the coefficients on the with-kids-sample using as housework division variable the composite indicator with housework and childcare activities (column 5).
Given the number of interactive variables that are included in our models, we can not directly interpret the coefficients reported in Table 2 but rather total effects and non-linearity analysis.[19] In order to clearly illustrate the results, we have drawn Figure 7 and Figure 8 reporting the results of the columns (3) and (4) respectively. These figures show the effect of the lockdown across the four different confinement situations and for all the possible values of the $Share_{it}$ variable.[20] We also present in these figures the distribution of $Share_{it}$ during the lockdown across the subsample as well as the number of respondents in each confinement situation.

In the Figure 7 for couples without kids, we observe that only situations in which the woman was at home during the lockdown (87 per cent of women without kids) lead to a significant increase in the occurrence of the conflicts (Panels (a) and (c)). These effects become significant and positive when women did more than three quarters of the housework. Even if positive, the magnitude is low for couples where both partners stayed at home. In both these two confinement situations, few households are affected by the situation of an increase of conflicts during the lockdown due to the housework division because conflictual situations appeared only for the very unbalance cases of housework distribution.

For couples with kids, Figure 8 shows that there is a significant and positive relationship between women's share of housework during the lockdown and the increase of conflicts regardless of the couple's confinement status. When both partners worked outside during the lockdown, the effect is only significant and positive for extreme unequal intrahousehold distribution, i.e. for which women did almost totally the housework. Only a few sample couples (161) are in this confinement situation. When only the father was working outside, the turning point in the womens' share of housework from which we observe a significant effect on conflict is lower than in the previous situation (72 per cent), indicating that the tolerance for an unequal distribution of chores is lower in this case. In this subsample, most of the couples of this subgroup experienced conflictual situation, because of the large prevalence of an unequal housework division during the lockdown. Finally, when the

[19] Because of all the interactive terms into the Eq. 2, θ captures the effect of the lockdown when both $Share_{it}$ and $Status_s$ are equal to 0. The magnitude of the coefficient β measures the average effect, giving us the intuition whether the lockdown has a significant different effect conditionally to the value of the women's share and compared to the situation where the women's share equals zero (represented by the coefficient θ). As $Share_{it}$ is a continuous variable from 0 to 1, we need to perform non-linearity analysis according to the value of this variable in order to interpret the total effect. Moreover, as we included interactive terms between the lockdown dummy and the couple's confinement status among the controls, we also need to interpret each couple's situation during the pandemic.

[20] Concretely for couples with both partners at home ($Status_s = 0$), it means interpreting total effects $\theta + \beta \cdot Share_{it}$, and computing this combined coefficients' values and standard errors for each potential value of $Share_{it}$ between 0 and 1; for couples where the woman was working outside during the lockdown $\theta + \beta \cdot Share_{it} + \gamma Status_s =$ only woman working outside; when the man was working outside: $\theta + \beta \cdot Share_{it} + \gamma Status_s =$ only man working outside; and when both were working outside: $\theta + \beta \cdot Share_{it} + \gamma Status_s =$ both partners working outside.

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father stayed at home (i.e. when both parents stayed at home or only the mother was working outside), even a slight imbalance of the housework distribution leads to an increase of conflicts during the lockdown. Couples with partners both at home and couples with woman as the sole outside worker do not diverge on the housework threshold above which the division increased the occurrence of conflicts (respectively 59% and 56% of the women's share of housework). However notable differences emerge in the magnitude of the effects: as expected the effect is stronger when only father stayed at home, meaning that the risk of conflict is higher in this case. Adding the childcare division to our variable of interest, we find similar results, that are presented in column 5 of Table 2 and illustrated in the Figure A3.[21]

The divergence of housework threshold among the confinement statuses highlight different tolerance thresholds for an unbalanced division of household chores, higher when the male was working outside than when it was the female. This evidence could raise the issue of a continuity of the legitimization of the male status into the households. Even during the lockdown, when household chores quantitatively increased, males keeped their privileged position. Indeed, more conflictual situations are likely to appear only with a very high imbalance when they are outside, therefore legitimizing their potential non-participation in housework.

We then look in detail at the role of each activity in the occurrence of the tensions among parents.[22] Running the same model as in Eq. 2, we replaced the variable of interest, $Share_{it}$, by each share of the housework and childcare tasks done by the women. Estimated coefficients are presented in Appendix, Table A3. As for the previous models, we cannot directly interpret the results using the unique coefficients. Once computed global coefficients and standard errors, we graphically illustrate the results for each of the four confinement status in Appendix Figure A4 for couples where both parents stayed at home, Figure A5 (Figure A6) for couples when the mother (father) was the only to work outside, and Figure A7 for couples when both parents worked outside.

For this latter situation, we find a significant and positive effect only for the activity named playing with children and exclusively for a very unequal division of the task. For all the other situations of confinement, increasing the woman's participation in any household chores during the lockdown increased the occurrence of intrahousehold conflicts. Remarkable differences emerge across activities, the magnitude of coefficients is systematically higher and the slope steeper for cleaning and for the two activities related to childcare. Indeed we can observe in Table A3 that for these three activities the average effect is significant at conventional confidence levels.

This means that conflicts in the couples particularly arose during the lockdown when women increased their participation in house cleaning and in childcare. Concentrating most of the housework time and being female-connoted, cleaning is perceived by women as the domestic activity which has fuelled the intrahousehold conflicts. Looking from the opposite side, we could say that an increase in male participation in these activities would significantly reduce the conflict between spouses in the lockdown period. Only a marginal reduction of conflicts is predicted when men increased their participation in the other household task, included shopping.

This indicates that the increased partner's contribution, notably in shopping, that was observed during the lockdown (see Section 3.2) did not allow to reduce significanly conflicts between partners. It is likely

[21]The only difference is that the tolerance threashold lowers to 85 per cent when both partners worked outside when childcare is included in the index.

[22]Because of the small effects we found on couples without kids, here we only focus on couples with kids.

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that the male's involvement in shopping is not considered as tough enough to balance the increase in the woman's burden during the lockdown. This last finding weakens the first explanation that we advanced in Section 3.2, and illustrate that the change of behaviour that we could assess from the male partner is rather circumstantial than structural, i.e. does not challenge the gendered stereotypes at home.

Table 2: Lockdown and effects of the household chores division on the occurrence of conflicts

	Full sample		No Children	With Children	
	(1)	(2)	(3)	(4)	(5)
Lockdown	0.0810**	-0.142	-0.167	-0.0910	-0.257**
	(0.0288)	(0.0937)	(0.148)	(0.108)	(0.0923)
Housework share		0.0414	0.0320	0.0633	
		(0.158)	(0.312)	(0.238)	
Housework Share × Lockdown		0.338**	0.277	0.375***	
		(0.118)	(0.198)	(0.0983)	
Housework and Childcare Share					-0.104
					(0.227)
H. and C. Share × Lockdown					0.625***
					(0.117)
Woman outside × Lockdown	0.0545	0.0667	0.0627	0.0641	0.0812
	(0.0935)	(0.0961)	(0.194)	(0.0581)	(0.0550)
Partner Outside × Lockdown	0.0501	0.0209	0.0958	-0.0586	-0.0766
	(0.0441)	(0.0458)	(0.0646)	(0.0958)	(0.0996)
Both Outside × Lockdown	-0.0162	-0.0332	0.0506	-0.117	-0.121
	(0.0676)	(0.0646)	(0.131)	(0.0820)	(0.0806)
Observations	5,688	5,688	2,458	3,230	3,230
R-squared	0.507	0.512	0.511	0.517	0.521
Labor Market Controls	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effect	Yes	Yes	Yes	Yes	Yes

All results were estimated using fixed effects model based on panel data from EICM online survey collected in France from April 21 to 10 May 2020. Sample selection retains only partnered women respondents. Lockdown is a variable equal to one for confinement period. "Housework share" is the average share of housework done by the woman in the household, hence related to the intrahousehold housework division. "Housework and Childcare Share" is an index combining both latter measures. Columns 1 to 2 present results on the full sample selection. Column 3 focus on couples without children. Columns 4 to 5 present results on the subsample of couples with at least one child.

All specifications use the covariates of the Eq. 1. We include the $Status_s$ referring to the confinement status of the members of the household as presented in Section 3.1. $Status_s$ are interacted with $Lockdown_t$ and presented according to the label of the category. The category of reference is when both partners stayed at home during the lockdown. Other covariates are related to the women and partners' labor market participation.

Each estimates controls for individual fixed effects. Standard Errors in parentheses are clustered at regional level. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively.

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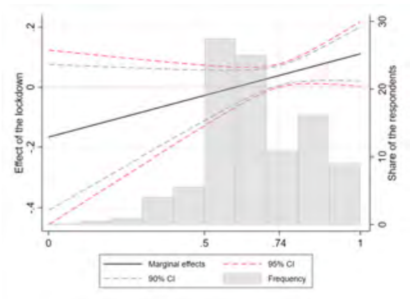
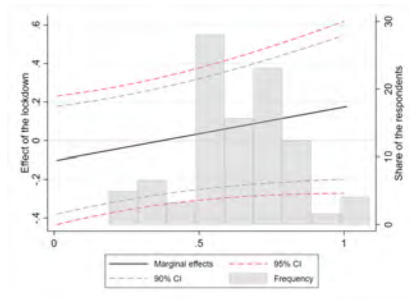
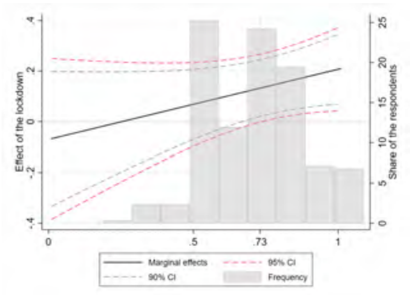


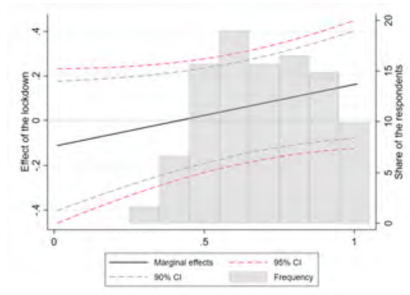
(a) Both at home (N=695)



(b) Woman outside (N=121)



(c) Man outside (N=293)



(d) Both outside (N=121)

Figure 7: Effects of housework division on conflicts - Couples without children

Note: These figures present total effects of the housework division during the lockdown on the conflict occurrence between partners for couples without children. These effects are directly computed from the coefficients presented in the column 3 of the Table 2.

5 Conclusion

The allocation of household chores within couples is typically stable over time, with a gendered connotation of a large number of tasks (Akerlof and Kranton, 2010). The Covid-19 epidemic, and the ensuing lockdown that has been adopted in Spring 2010 by a large number of countries, has brought a sudden and unprecedented shock to this stable allocation. The lockdown has changed the amount of household chores to be performed, notably with a major increase in the time devoted to children who were constrained to home schooling, and with a reduced reliance on domestic workers. The time spent by french women doing housework increased by about 30 per cent, while they multiplied on average by three the time in helping children with their homeworks. The lockdown has also modified the opportunities to perform household tasks, and it has also given a "quasi-leisure" connotation to some household chores at a time in which the opportunity for usual leisure activities (or for simply going out of home) was greatly limited. Furthermore, the anxiety for the evolution of the epidemic and of its ensuing economic consequences, the disruption of social life and a forced cohabitation also contributed to increase the likelihood of the occurrence of conflicts and tensions between partners, which might have been intertwined with the unequal character of the allocation of the (increased)

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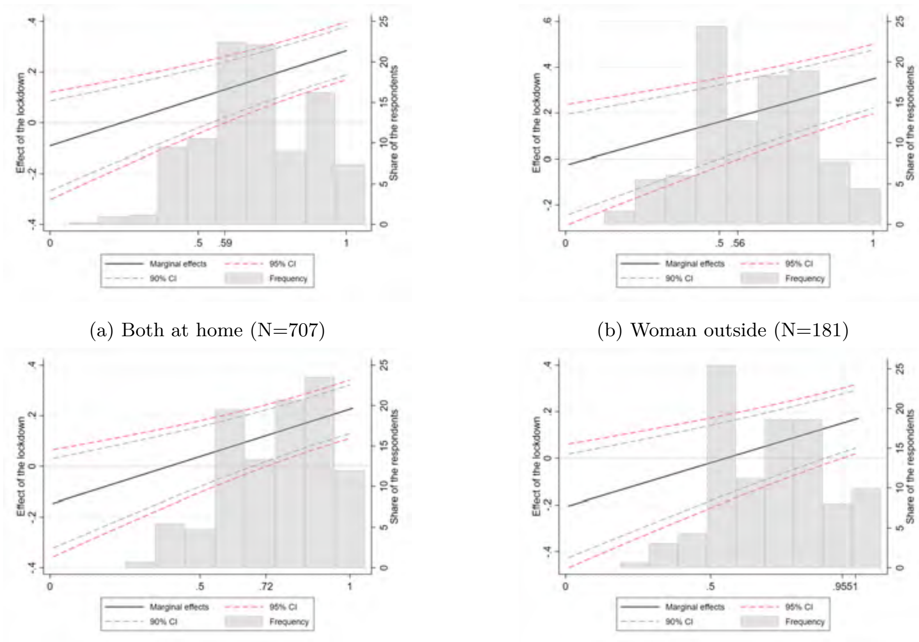

(a) Both at home (N=707)

(b) Woman outside (N=181)

(c) Man outside (N=569)

(d) Both outside (N=161)

Figure 8: Effects of housework division on conflicts - Couples with children

Note: These figures present total effects of the housework division during the lockdown on the conflict occurrence between partners for couples with children. These effects are directly computed from the coefficients presented in the column 4 of the Table 2.

burden of household chores.

Based on original collected data during the Spring 2020 confinement in France, we investigated (i) if and how the first lockdown induced a (re)division of household chores between french partners and (ii) if there was a relationship between household chores (re)division and intrahousehold conflict.

The data analysis reveals that typical roles in the allocation of the household chores between couples have persisted in France. Women have taken care of most of the household chores, from 60 to 80 per cent according to the task, with a lower male participation in laundry, cleaning and in doing homeworks with kids (activities that individuals usually dislike). The confinement did not changed this situation as the gender gap remained positive for all activities surveyed.

During the lockdown, substantial heterogeneities were observed on the task (re)distribution and conflicts among partners, notably according to the presence of children in the household and to the confinement status of the couple (i.e. if one, or both, or no partner was confined at home).

For the couples without kids, we did not observe on average any redistribution of household tasks. In that case, conflictual situations only increased with the share of work done by women for couples with an extremely unequal allocation of household chores, and when women were at home during the lockdown.

For couples with kids, we also do not observe any changes in household chores division when both partners worked outside, except a small increase of father's engagement helping kids with homework. Conversely, when only one of two was staying at home, due to the unemployment or the remote working, this member increased its share in household chores. This is particularly clear when the female was the sole outside worker of home, because male's participation increased substantially in all tasks except in shopping. When man was the sole partner working outside, a disaggregation by tasks allowed us to observe that the increase in their participation in shopping was important in magnitude, and compensated the decrease in the participation in the other tasks. When both partners were confined at home, which count for 44 per cent of our sample parents, we observed a reallocation of tasks in favor of women but this effect was only led by two activities: shopping and playing with kids. For the other tasks, we indeed observed a statu quo in their division.

Facing to an quantitative increase of household chores, it is likely that fathers who were at home during the lockdown felt compelled to increase their domestic contribution. Nevertheless, when possible (i.e. when women was at home), they preferred to increase only participation in activities already considered as enjoyable (as playing with kids, the task for which the gender gap was lower even before lockdown) or that became enjoyable given the limited set of activities out-of-home allowed during the lockdown (as shopping).

Conflicts among partners with kids increased with the share of household chores done by women, in particular when men stayed at home during the lockdown. Childcare and cleaning concentrated most of the tensions in the household, meaning that the unequal division of chores in these activities was perceived by women as a real intrahousehold inequality. This allows us to conclude that redistributing the burden of household activities during a stressful period, as the lockdown, helps to limit the disputes between partners, but the activities in which men engage are not neutral, i.e. conflicts do not notably decrease if men are involved in activities mostly seen as a leisure or "quasi-leisure".

According to our analysis, men behave in accordance to their gender role but their preferences are not stable, they adapt themselves to the contingent situation. A female-connoted activity like shopping became an almost exclusive prerogative of males when it gains in attractiveness. The gendered nature of a task seems thus to respond to its changing attractiveness rather than being a stable feature. This finding also illustrates that a possible change of male's preferences due to the constraints during the pandemic is able to modify the division of the household chores. However, this new negotiated equilibrium did not seem to be approved by women, since it did not imply a decrease in the risk of conflicts between partners. Our results indicate that women would rather prefer an higher men's involvement into less agreeable activities like cleaning. Finally, the lockdown missed the opportunity to redefine gendered roles at home and to impel a structural change at the intrahousehold level.

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6 Appendix

Table A1: EICM Survey and INSEE data

	EICM Survey		INSEE Data	
Population	N	Perc.	N	Perc.
AURA	1382	24.27	3,502,191	11,98
Bourgogne	316	5.55	1,285,025	4.40
Bretagne	286	5.02	1,503,368	5.14
Centre	254	4.46	1,152,027	3.94
Corse	12	0.21	146,103	0.50
Grand Est	558	9.8	2,457,718	8.41
HDF	418	7.34	2,519,188	8.62
IDF	452	7.94	5,141,444	17.59
Normandie	294	5.16	1,475,918	5.05
N. Aquitaine	478	8.39	2,742,949	9.38
Occitanie	526	9.24	2,662,784	9.11
P. Loire	294	5.16	1,639,994	5.61
PACA	408	7.17	2,268,086	7.76
Outre-Mer	16	0.28	740,094	2.53
Education (Shares)	N	Perc.		Perc.
High school diploma or less	3,404	59.85		75.4
Above high school diploma	2,284	40.15		24.4
Undetermined				0.2

Data survey are from EICM online collected in France from April 21 to 10 May 2020.

Statistics for French population at regional level are from INSEE - ”Le Recensement de la population” in 2016. N is the number of households. AURA is the acronym for Auvergne-Rhone Alpes. HDF is the acronym for Haut-de-France. IDF is the acronym for Ile-de-France. PACA is the acronym for Provence Alpes Cote d'Azur.

Education levels are data from INSEE - ”Enquete Emploi” in 2019. We combine several categories for comparison with our data. Education level called ”High School Diploma or less” gathers all respondents with a high school diploma at maximum. It means those with no education, a CAP, a Brevet (equivalent to apprenticeship or other professional diploma) or a french baccauréat (equivalent to an highschool level). Education level called ”Above high school diploma” gathers all respondents with a level higher than a french baccalauréat.

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Table A2: Summary statistics from the EICM survey

		Pre-lockdown		Lockdown	
	N	Mean	St. Dev.	Mean	St. Dev.
Shares (indexes)					
Woman's share of housework	2844	0.712	0.171	0.691	0.183
Woman's share of childcare	1615	0.680	0.184	0.668	0.206
Woman's share of housework and childcare	1615	0.715	0.147	0.691	0.164
Shares (single tasks)					
Woman's share of Shopping	2844	0.670	0.265	0.604	0.346
Woman's share of Laundry	2844	0.809	0.236	0.805	0.250
Woman's share of Cooking	2844	0.661	0.281	0.655	0.283
Woman's share of Cleaning	2844	0.706	0.236	0.701	0.248
Woman's share of Homeworks	1615	0.755	0.223	0.733	0.255
Woman's share of Playing with kids	1615	0.605	0.206	0.602	0.218
Conflicts					
Conflict between partners	2844	0.154	0.361	0.253	0.435
Panel covariates					
Woman is working	2844	0.758	0.428	0.564	0.496
Partner is working	2844	0.882	0.323	0.692	0.462
Confinement status					
Both at home	2844			0.453	0.498
Woman outside	2844			0.109	0.312
Man outside	2844			0.335	0.472
Both outside	2844			0.102	0.302

Data survey are from EICM online survey collected in France from April 21 to 10 May 2020. Sample retained for these summary statistics are only based on partnered women respondents.

"Woman's share" variables are directly linked to the housework division between partners. For each task, respondent could recall for the question "Who is doing the activity in the considered period ?" the following choices: "always me"; "me most of the time"; "equally"; "my partner most of the time"; "always my partner"; "another person". We attribute the value from 1 to 0, gradually to the women's involvement in the task. Then, we compute the average share done by the women in the global housework and childcare to obtain the indexes presented in the "Shares (indexes)" panel.

"Conflicts" is a dummy variable that takes the value of one for the period when the woman experiences a more conflictual relationship with her partner, and 0 for the other period.

"Panel covariates" are variables related to the labor market participation of the woman and her partner before and during the lockdown. These dummies are equal to one if the woman (partner) was working during the considered period.

"Confinement status" are variables equal to one if the couple were in the corresponding situation during the lockdown, 0 otherwise.

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Table A3: Conflicts and household chores division

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Lockdown	0.160**	0.0970	0.0711	0.0886	-0.0815	-0.122	-0.104
	(0.0597)	(0.0866)	(0.145)	(0.0663)	(0.102)	(0.0720)	(0.0599)
Shopping		-0.0345					
		(0.142)					
Shopping × Lockdown		0.106					
		(0.0799)					
Laundry			0.0262				
			(0.171)				
Laudry × Lockdown			0.112				
			(0.112)				
Cooking				0.169			
				(0.119)			
Cooking × Lockdown				0.117			
				(0.0884)			
Cleaning					-0.0211		
					(0.122)		
Cleaning × Lockdown					0.351***		
					(0.101)		
Homeworks						-0.289*	
						(0.152)	
Homeworks × Lockdown						0.386***	
						(0.0988)	
Play							-0.119
							(0.187)
Play × Lockdown							0.456***
							(0.132)
Woman Outside × Lockdown	0.0389	0.0340	0.0500	0.0619	0.0727	0.0649	0.0598
	(0.0571)	(0.0615)	(0.0580)	(0.0610)	(0.0481)	(0.0438)	(0.0479)
Partner Outside × Lockdown	-0.0245	-0.0307	-0.0357	-0.0471	-0.0585	-0.0501	-0.0542
	(0.0928)	(0.0878)	(0.0923)	(0.0957)	(0.0934)	(0.0963)	(0.0933)
Both Outside × Lockdown	-0.102	-0.108	-0.107	-0.102	-0.117	-0.112	-0.110
	(0.0800)	(0.0812)	(0.0803)	(0.0802)	(0.0821)	(0.0764)	(0.0774)
Observations	3,230	3,230	3,230	3,230	3,230	3,230	3,230
R-squared	0.510	0.512	0.511	0.514	0.518	0.518	0.520
Labor Market Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes

All results were estimated using fixed effects model based on panel data from EICM online survey collected in France from April 21 to 10 May 2020. Sample selection retains only partnered women respondents. Lockdown is a variable equal to one for confinement period. Each column present as variable of interest the share done by the woman in their household for the considered chore interacted with the lockdown variable.

All specifications use the covariates of the Eq. 2. We include the $Status_s$ referring to the confinement status of the members of the household as presented in Section 3.1. $Status_s$ are interacted with $Lockdown_t$ and presented according to the label of the category. The category of reference is when both partners stayed at home during the lockdown. Other covariates are related to the women and partners' labor market participation.

Each estimates controls for individual fixed effects. Standard Errors in parentheses are clustered at regional level. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively.

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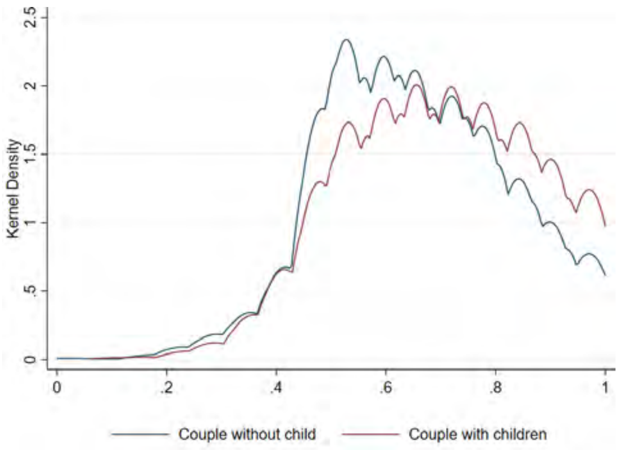

Figure A1: Kernel density of the average share of the tasks

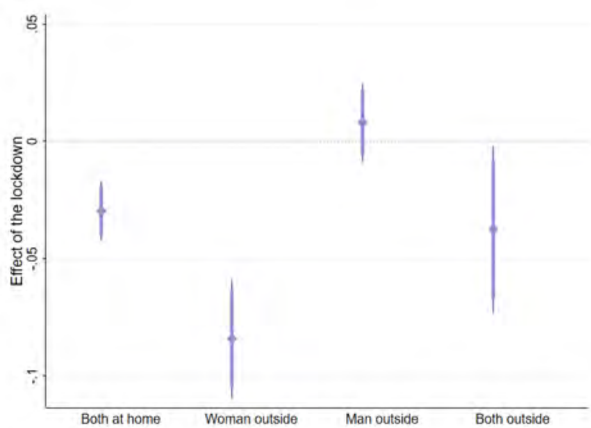

Figure A2: Effects of the lockdown on the housework and childcare division - Couples with children

Note: This figure presents the effects of the lockdown on the household chores (housework and childcare) division between partners on the subsample of couples with children. Marginal effects of the lockdown are directly computed from the coefficients presented in the Table 1, column 5, setting for different values of $Status_s$, confinement status of the couple, *i.e.* "both at home" ; "woman outside" ; "man outside" ; "both outside".

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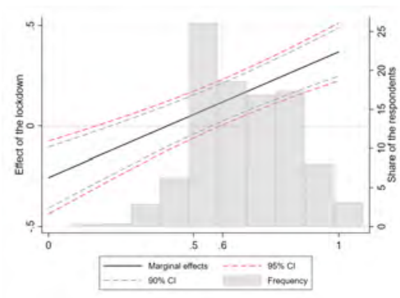
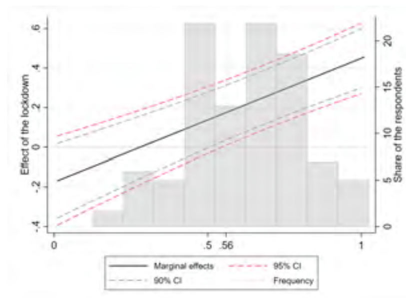
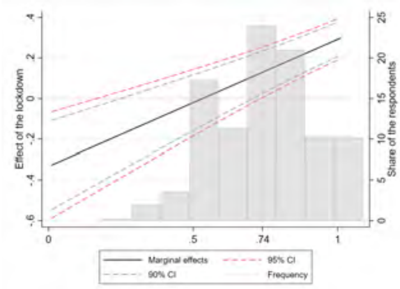


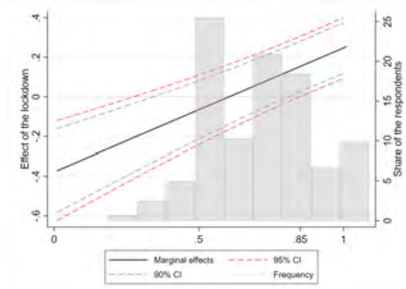
(a) Both at home (N=707)



(b) Woman outside (N=181)



(c) Man outside (N=569)



(d) Both outside (N=161)

Figure A3: Effects of housework and childcare division on conflicts - Couples with children

Note: These figures present total effects of the housework and childcare division during the lockdown on the conflict occurrence between partners for couples with children. These effects are directly computed from the coefficients presented in the column 5 of the Table 2.

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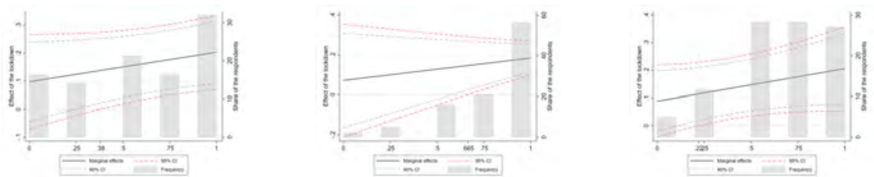
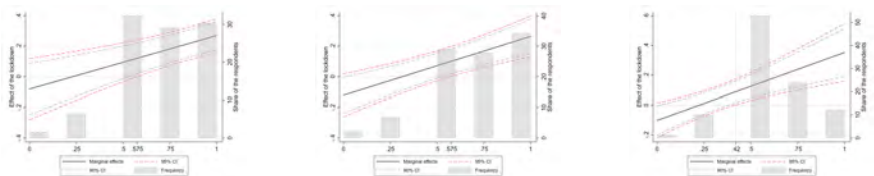


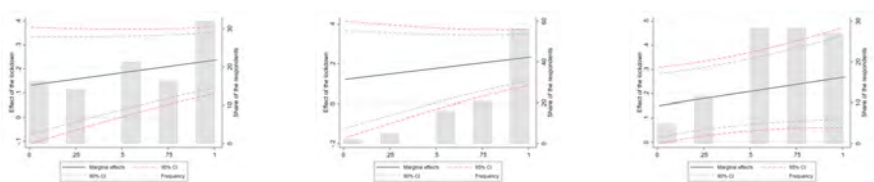
(a) Shopping (b) Laundry (c) Cooking



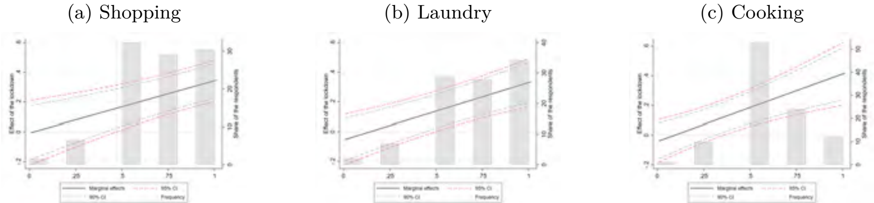
(d) Cleaning (e) Homework (Children) (f) Playing (Children)

Figure A4: Effects of housework division on conflicts - Couples with children and both staying at home

Note: These figures present total effect of the household chores division during the lockdown on the conflict occurrence between partners. Total effects are directly linked to the coefficients presented in the Table A3 when $Status_s$ is equal to 1 when both partners were confined at home.



(a) Shopping (b) Laundry (c) Cooking



(d) Cleaning (e) Homework (Children) (f) Playing (Children)

Figure A5: Effects of housework division on conflicts - Couples with children and woman working outside

Note: These figures present total effects of the household chores division during the lockdown on the conflict occurrence between partners. Total effects are directly linked to the coefficients presented in the Table A3 when $Status_s$ is equal to 1 when the woman was the sole outside worker during the lockdown.

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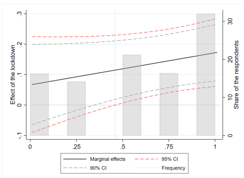
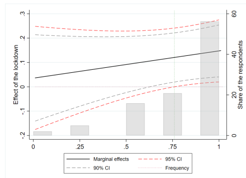
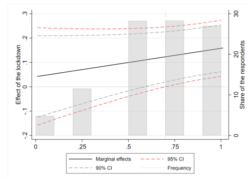


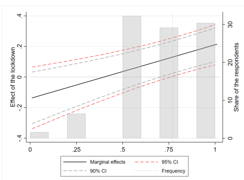
(a) Shopping



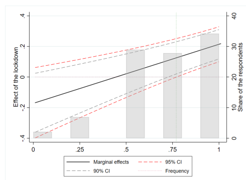
(b) Laundry



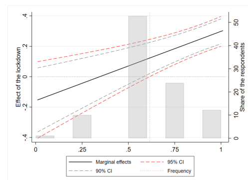
(c) Cooking



(d) Cleaning



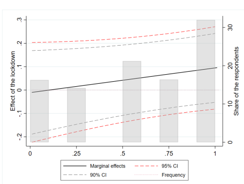
(e) Homework (Children)



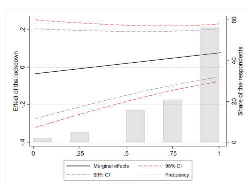
(f) Playing (Children)

Figure A6: Effects of housework division on conflicts - Couples with children and man working outside

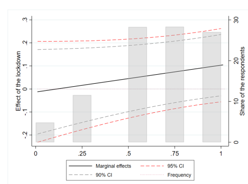
Note: These figures present total effects of the household chores division during the lockdown on the conflict occurrence between partners. Total effects are directly linked to the coefficients presented in the Table A3 when $Status_s$ is equal to 1 when the man was the sole outside worker during the lockdown.



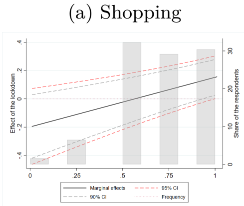
(a) Shopping



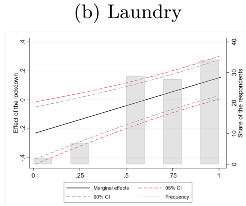
(b) Laundry



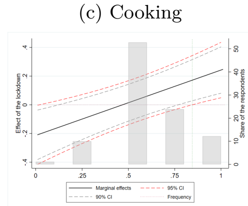
(c) Cooking



(d) Cleaning



(e) Homework (Children)



(f) Playing (Children)

Figure A7: Effects of housework division on conflicts - Couples with children and working outside

Note: These figures present total effects of the household chores division during the lockdown on the conflict occurrence between partners. Total effects are directly linked to the coefficients presented in the Table A3 when $Status_s$ is equal to 1 when both partners were working outside during the lockdown.