What Policies Address Both the Coronavirus Crisis and the Climate Crisis?

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Abstract

The coronavirus pandemic has led many countries to initiate unprecedented economic recovery packages. Policymakers tackling the coronavirus crisis have also been encouraged to prioritize policies which help mitigate a second, looming crisis: climate change. We identify and analyze policies that combat both the coronavirus crisis and the climate crisis. We analyze both the long-run climate impacts from coronavirus-related economic recovery policies, and the impacts of long-run climate policies on economic recovery and public health post-recession. We base our analysis on data on emissions, employment and corona-related layoffs across sectors, and on previous research. We show that, among climate policies, labor-intensive green infrastructure projects, planting trees, and in particular pricing carbon coupled with reduced labor taxation boost economic recovery. Among coronavirus policies, aiding services sectors (leisure services such as restaurants and culture, or professional services such as technology), education and the healthcare sector appear most promising, being labor intensive yet low-emission—if such sectoral aid is conditioned on being directed towards employment and on low-carbon supply chains. Large-scale green infrastructure projects and green R&D investment, while good for the climate, are unlikely to generate enough employment to effectively alleviate the coronavirus crisis.

1 Introduction

As decision makers around the world scramble to respond to the coronavirus crisis and the deep and possibly prolonged recession that follows it, commentators have called for them to use the opportunity to also further our progress in mitigating climate change, which a majority of people believe to be as serious a crisis as the coronavirus (Ipsos, 2020). By pursuing policies that can both alleviate the economic recession caused by the coronavirus and help reduce greenhouse gas emissions, the current crisis presents an opportunity to put the world on a new trajectory with a lower risk of future climate calamities. Crisis management often requires exceptional policies, and may temporarily alter constraints on decision making. Strategic vision at such a time can help decision makers take into account longer-term objectives, which might be difficult to meet under normal circumstances. As Rahm Emanuel famously said, "You never want a serious crisis to go to waste".

Yet, for climate policies to have a chance of implementation at this moment, they cannot be at odds with addressing the current crisis. In this paper, we seek to systematically identify where the intersection between 'coronavirus policies' and 'climate policies' lies. We are interested in which types of policies can help mitigate the impacts of the coronavirus crisis, and also make headway in setting societies on low-carbon pathways. We intentionally focus on long-term climate impacts. Many coronavirus policies have temporary effects on carbon emissions (e.g., reduced traffic due to a lockdown), but we see such temporary effects as unimportant, given the long timescales involved in anthropogenic climate change (Le Quéré et al., 2020).

Specifically, our contribution is the following. We first identify policies which alleviate the coronavirus crisis, as well as a set of channels through which relatively short-term policies can have impacts on climate change in the longer run. Second, we present data on sector-specific economic activity and emissions. We then use these tools, together with previous research, to evaluate and score policies in terms of their usefulness in tackling the climate and coronavirus crises. Policies ranked as 'good for climate' should be expected to yield substantial long-run emission reductions. Policies ranked as 'good for coronavirus recession' should help alleviate the job losses due to the current recession and (in some cases) have public health benefits regarding current or future pandemics. We present a set of policies that can help reduce the economic fallout of the coronavirus crisis, and simultaneously aid societies in meeting climate change mitigation targets in the longer run. We hope this exercise can help policymakers think through their policy options if they want to chart a 'green recovery' while dealing with the coronavirus crisis.

'Green stimulus' is of course not a new term. In the wake of the financial crisis of 2008-2009, Strand and Toman (2010) evaluated potential stimulus policies in terms of their potential to improve long-term environmental outcomes. Some of their recommendations are still valid. However, for the current crisis one has to evaluate policies that are specific to it, i.e., that are adapted to the health aspects of the coronavirus, and the unprecedented economic shock of a simultaneous sharp fall in

both demand and supply. Hence, our set of policies differ from Strand and Toman (2010). We also consider some channels for long-run impacts that they did not touch upon. Other, more recent, analyses (e.g., CAT, 2020) outline the climate effects of various policies, but ignore whether any of the policies (such as green R&D) are actually good at alleviating the coronavirus crisis. The paper by Hepburn et al. (2020) has a similar objective to ours, but their analysis starts from previously used stimulus policies (since the financial crisis of 2008-2009) and is based on surveys of expert opinions. We start from policies that seem especially appropriate in the current crisis, and evaluate them based on an analysis of the individual policies, combined with basic empirical observations about the carbon, labor and layoff intensity of different sectors and jobs.

We want to defuse two potential criticisms against the notion that crisis policies should be evaluated based also on their effect on environmental outcomes. The first relates to the Tinbergen Rule: that, to obtain an efficient outcome, one needs as many instruments as there are externalities. In particular, policymakers should use one set of instruments to deal with the health crisis, another to achieve macroeconomic stabilization, and a third to achieve long-term environmental objectives.

In a first-best world this would of course be true. In practice there are constraints—practical and political—that make perfect fine-tuning difficult. Given such constraints, we have to ensure that measures to address one goal do not undermine another. We illustrate with two examples from our analysis. First, implementing a carbon tax would, if done in isolation, likely worsen the current recession. But if the proceeds were used to lower labor taxes, the policy could instead alleviate the coronavirus crisis. Second, economic stabilization will involve government investment, or subsidies to private investment, into capital assets. The question is then: which types of capital assets? The answer necessarily has to account for the effect the assets will have on the climate.

The second criticism is that beneficial long-term effects on climate are unlikely to be achieved in the absence of long-term policies to price externalities (Strand and Toman, 2010). Our immediate answer is that we include tax and subsidy reforms in our set of policies. A further riposte, indeed to both of the above criticisms, is that long-term pricing policies are endogenous: policies today affect what is politically feasible tomorrow (Acemoglu and Robinson, 2013).

2 Approach for analysis

Our goal is to evaluate policies in terms of their potential to mitigate the economic fallout of the coronavirus pandemic, and their long-term effect on climate change. To this end, we start by discussing what types of policies can help deal with the consequences of the pandemic. We then present channels via which relatively short-term policy interventions can have longer-run impacts on climate change and climate policy. These two classification exercises allow us to identify policies that have effects on both crises. We then present some data that will be useful in evaluating policies.

2.1 Policies for mitigating the coronavirus pandemic

When people are forced to stay at home they do not go to work and they consume less. The inability to work is a supply shock, while the reduction in consumption is a demand shock. The combination of the two implies bankruptcies and layoffs, aggravating income losses and lowering demand even further. The supply shock will disappear as an improving understanding of the coronavirus allows for more targeted public health measures, and eventual control of the pandemic. However, the economic effects on aggregate demand are likely to persist, so that the demand shock will outlive the supply shock. We mainly focus on policies implemented in the medium term, and thus centered around the economic recovery, rather than around pandemic control per se.

Economic stimulus policies—in particular, ensuring high demand by supporting incomes and employment—will be central for mitigating the economic fallout. It is well established empirically that wealthy capital owners tend to save a larger share of their income than people who are poorer and who rely on labor income (see e.g. Bernheim and Scholtz, 1993; Beverly, 1997; Browning and Lusardi, 1995; Dynan et al., 2004; Diamond and Hausman, 1984; Gentry and Hubbard, 2004; Quadrini, 2000; Alan et al., 2015; Dupas and Robinson, 2015; Gandelmann, 2017). Hence to assess the potential of a policy to restart the economy, we will evaluate policies based on their potential to secure employment (which also benefits mental health) and labor income.

Some of the firms that now go bankrupt may not be able to quickly resume their old activities once the health crisis is over. It may take time for firms and labor to match, for investors and firms to match, and so on. Helping businesses survive will reduce such frictions. For this reason, policies that reduce bankruptcies can also help the recovery. Unfortunately, data on bankruptcies are not yet readily available. We conjecture (based, e.g., on Andersen et al., 2020, Carvalho et al., 2020, and our own analysis using preliminary data, see Appendix A.1) that bankruptcies are highly correlated with layoffs.

2.2 Channels for long-run climate impacts

Policies may have long-run implications on climate change through a variety of channels. We have identified four channels we see as particularly relevant for our purpose.

1. **Investment – Direct effect of long-lived investments.** To mitigate the unprecedented economic crisis, governments are planning to stimulate economies through massive investment programs, either implemented directly by governments, or by subsidizing private-sector investments. Such investments have direct long-run impacts once sunk: some will be long-lived, and either substitute or complement fossil fuels (e.g., power generation or transportation infrastructure). Once made, they will be used, and thus have long-run impacts on baseline emission pathways and on the cost of implementing future climate policies (Shalizi and Lecocq, 2009; Seto et al., 2016).

2. **Political – Dynamic political economy effects.** Policy can be persistent: economic decisions taken by firms, in response to policies intended to be temporary, can affect political incentives, preventing a future reversal of a policy (Coate and Morris, 1999). This can happen as an indirect effect of sunk investments which changes the structure of vested interests (with respect to climate policies): a devaluation of fossil-related assets, or the introduction of new assets complementary to climate policies, will affect the power and incentives of interest groups to influence future policies (Acemoglu and Robinson, 2013). Similar effects could result from the destruction of interest groups, e.g. due to bankruptcies in a sector that receives little stimulus money. The formation of special interest groups may also prove to be a self-fulfilling prophecy (Grey, 2018), and short-term disruptions to interest group formation can have long-run effects.

3. **Technological – Path dependence due to technological development.** A further indirect effect may arise through changes in the direction of R&D (e.g. low carbon versus carbon intensive). When technological change is directional, temporary policies may determine in which direction an economy develops. Such differences can persist: temporary growth in one type of technology may sustain itself, due to innovation incentives being geared towards a dominant technology, and due to complementarities in R&D (Acemoglu et al., 2012; Hart, 2013; van der Meijden and Smulders, 2017).

4. **Learning – Forced experimentation and learning effects.** Consumers and producers may not perfectly optimize their choices, e.g. due to costs of finding out about the characteristics of various options, because of biases in decision making, institutional constraints, or because of habit formation favoring status quo behavior. Temporary disruptions to choice sets may force them to look for new options, which may be preferred after the disruption has ended (Seto et al., 2016; Larcom et al., 2017). Policies that promote or subsidize experimentation can help a wider set of agents explore novel options, and thus promote permanent changes in behavior.

2.3 Data

We focus on two metrics for alleviating the coronavirus crisis: the number of layoffs in an industry and the labor intensity of the industry, expressed in employees per unit of value added. For judging the climate effects, we focus on the emissions intensity of an industry: climate goals suggest the long-run prospects of relatively clean industries should be prioritized. We use two empirical metrics: emissions per unit of value added, and per employee.

We collect data on emissions, number of employees and value added by sector from Eurostat. Layoffs data are from national sources: Swedish Public Employment Service for Sweden; the Helsinki GSE Situation Room for Finland.[1] We show results for labor and emissions intensity for

[1] Sweden: https://arbetsformedlingen.se/om-oss/statistik-och-analyser/statistik. Finland: https://www.helsinkigse.fi/korona-data/.

the European Union, Germany, France, the United Kingdom, Sweden and Finland. Our results for layoffs are limited to the countries for which we could find reliable data on recent layoffs during the coronavirus recessions (Sweden and Finland).[2] These roughly correlate with productivity and demand declines (see Appendix Figure A2).

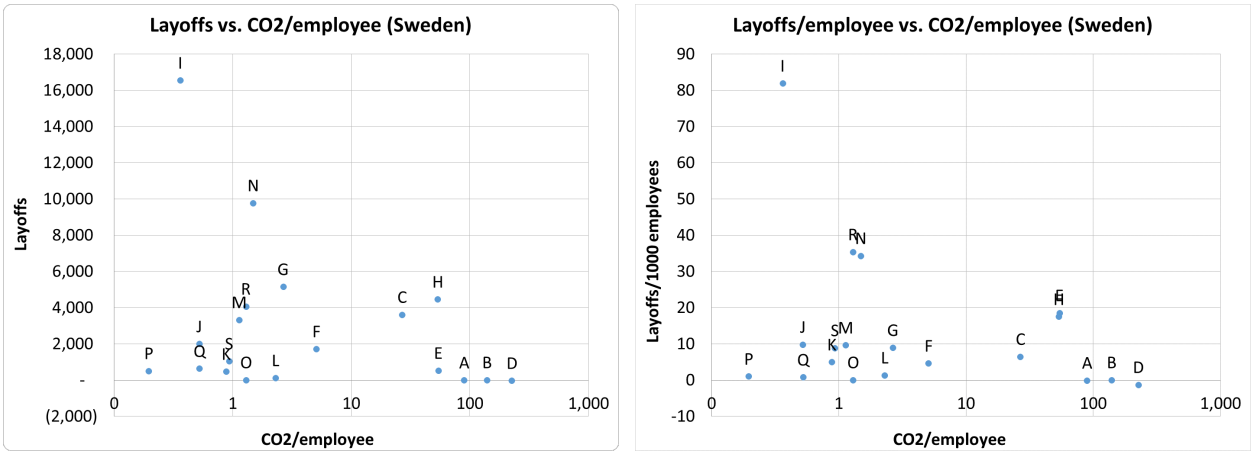
A	Agriculture, forestry, fisheries	K	Finance and insurance
B	Mining	L	Real estate
C	Manufacturing	M	Legal, economics, R&D and technology
D	Electricity and heating	N	Rental, real estate services, travel services and other support
E	Water and sanitation	O	Public administration
F	Construction	P	Education
G	Wholesale and retail trade	Q	Healthcare and elder care
H	Transport and storage	R	Culture, entertainment and hobby
I	Hotels and restaurants	S	Other services
J	Information and communication		

Table 1. Sector definitions used in the empirical analysis.

Figure 1 plots both layoffs and layoffs per thousand employees against CO_2 emissions per employee (note the logarithmic scale on the horizontal axis) for the sectors given in Table 1. The most affected sectors in Sweden, in terms of total layoffs, are I (hotels and restaurants), G (wholesale and retail trade), H (transport and storage), N (rental and real estate), and R (culture). Some of these show large layoffs simply because of their size. When layoffs are normalized per 1,000 employees, the same sectors stand out except that sector E (water and sanitation) is badly affected while sector G (wholesale and retail trade) appears less affected. The picture for Finland is broadly similar, except that there are more layoffs in sector C (manufacturing).

[2] For the EU there are no aggregate data on layoffs. The United States does not report CO_2 emissions data at the required level of sectoral detail. We therefore exclude it from the analysis. We do present layoff data by sector for the United States in Appendix A.1, which are highly correlated with layoffs in Sweden and Finland.

Panel A: Sweden



Panel B: Finland

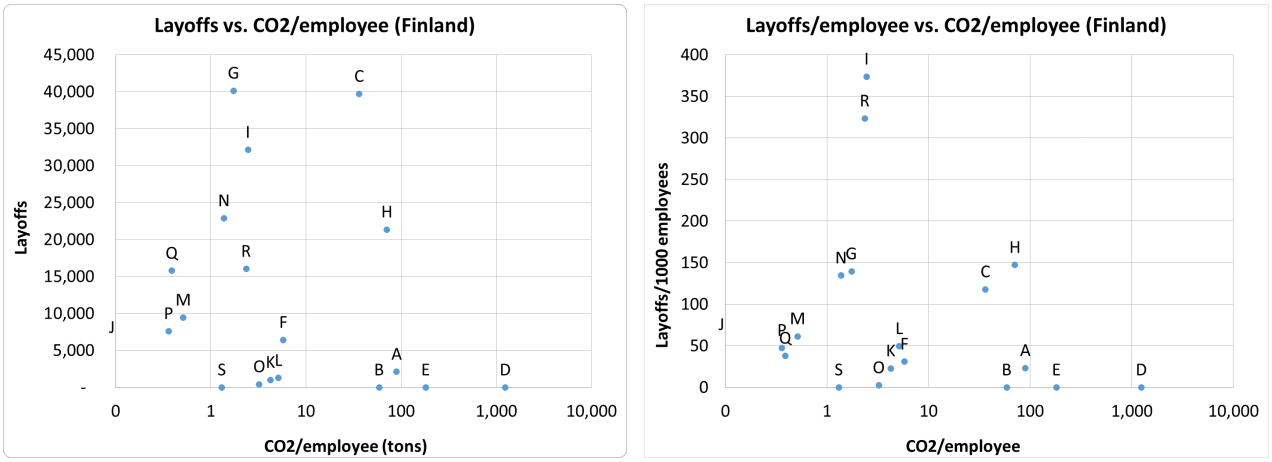


Figure 1. Layoffs (graphs on the left) and layoff intensities (graphs on the right) vs. CO_2 emissions (in tons) per employee, by sector, for Sweden (Panel A) and Finland (Panel B).

Notes: Figure shows excess layoffs for the period March 1st-April 17th, 2020 for Sweden (compared to January and February); for the period March 15th-May 19th, 2020 for Finland (compared to the same period in 2019). Data on CO_2 emissions and employees by sector are from Eurostat.

We emphasize that this is a high-level categorization which masks detail—yet it serves as a useful benchmark for stimulus and other policy decisions. We specifically highlight three caveats. First, CO_2 intensity is measured in a narrow sense. For example, hotels have a low emissions intensity as the emissions from associated travel is allocated to the transport sector, but clearly hotels facilitate (carbon-intensive) travel. Second, layoffs are a recent snapshot and may be temporary. Figure 1 is likely to change over the course of the coronavirus recession, and might look very different several years from now. Finally, there is within-industry heterogeneity which should be considered when applying detailed policy suggestions.

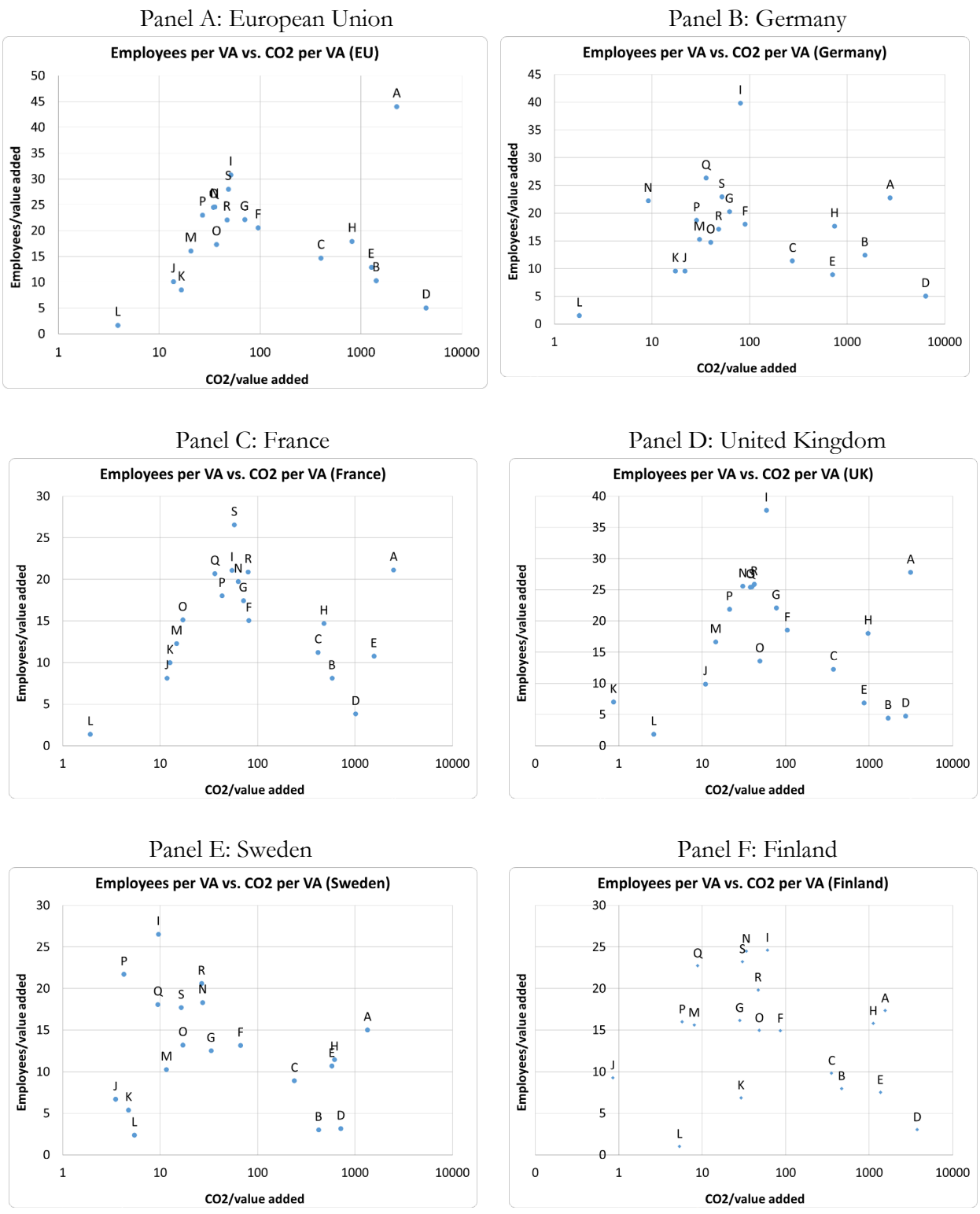


Figure 2. Employees per million euros of value added vs. tons of CO_2 per million euros of value added, by sector, for the European Union (Panel A), Germany (Panel B), France (Panel C), the United Kingdom (Panel D), Sweden (Panel E) and Finland (Panel F).

Notes: Figure shows data for calendar year 2017. Value added is in millions of euros. Source: Eurostat.

To overcome some of these concerns, Figure 2 plots a measure of labor intensity (employees per million euros of value added) against a measure of emissions intensity (CO_2 emissions per million units of value added) for each of the sectors in the European Union, Germany, France, the United Kingdom, Sweden and Finland. Per amount of stimulus spent, industries with high labor intensity may also be relevant to target from a recession perspective, since each unit of spending can be expected to have a larger employment effect in those sectors.[3] From the climate perspective, one would like to focus on sectors with low emission intensities.

The results vary somewhat across countries, but paint a remarkably consistent picture. First, there is a slight negative relationship between labor intensity and emissions intensity, perhaps reflecting that sectors with low labor shares rely on more energy-intensive capital. Industries that stand out as potential targets that score well on the coronavirus-climate interface are not necessarily the ones that have seen the most layoffs, although they overlap partially.

For the European Union as a whole, the set of high-labor, low-emissions sectors include I (hotels and restaurants), G (wholesale and retail trade), N (rental and real estate), Q (health care and elder care), P (education), R (culture) and S (services). Sectors I, G, N and R have also experienced a peak in recent layoffs. For each of the individual countries, almost the same set appear on the high-labor, low-emissions list. In Appendix A.2, we comment on these sectors individually, and end by commenting on some other industries.

3 Analysis

To structure our analysis we categorize policies along the following dimensions (Table 2). First, we split them into policies that are primarily motivated by their effects on the recession caused by the coronavirus pandemic vs. policies that are primarily motivated by climate change. Second, we classify policies into the following three categories: stimulus spending, tax reform and cross-cutting policies.

Stimulus spending refers to policies that require substantial amounts of government funds, with the aim to preserve employment, avoid bankruptcies, create new jobs, and help the hardest-hit consumers. The second category includes tax reform policies that are complementary or even somewhat orthogonal to stimulus, but that raise extra revenues that can be used as additional stimulus, and that have overall economic efficiency benefits. Third, some policies do not require large financial injections from the government; e.g., mandates, standards, or bans. They may also span several categories. We group them under 'cross-cutting' policies.

[3] There are several caveats to this type of policy focus, including preventing stimulus packages from being taken up by the owners without maintaining employment. We expand on this in section 3.1.1 below.

Any categorization of policies is necessarily imperfect: there is no optimal choice of dimensions and policies will spill across categories or overlap with each other. Policies vary in their breadth and budgetary requirements. The most important matter is that our list of policies is reasonably complete. We believe it is, with some caveats. We purposely omit some policies. We do not tackle coronavirus policies that have no long-run climate impacts, or that are not relevant beyond the immediate crisis. These include test-trace-isolate, travel restrictions, and vaccine development. Similarly, some central policies to manage the pandemic have significant but short-lived effects on emissions—yet long-run climate impacts appear highly limited. These include distancing policies such as lockdowns, restricting access to public spaces, and the closing of restaurants and schools.

CORONA POLICIES	**CLIMATE POLICIES**
Stimulus spending	**Stimulus spending**
Helicopter money, monetary stimulus and other redistribution (bad-to-good, unknown, A.3)	Small scale green infrastructure investment (good, good, A.4)
Aiding industries (see Figure 3 for a sector specific evaluation)	Large scale green infrastructure investment (neutral-to-good, good, A.4) Renewables R&D investment (neutral-to-good, good, A.5) Planting trees and maintaining national parks (very good, good, A.6)
Tax reform	**Tax reform**
Reduced labor taxes (good, neutral, A.7)	Revenue-neutral carbon pricing (good, very good, A.8) Tighter emissions caps (good, very good, A.11) Abolishing fossil fuel subsidies (good, very good, A.9) Taxing meat consumption (good, good, A.10)
Cross cutting	**Cross cutting**
Paying wages of private employees (very good, neutral-to-good, A.12) Extending sick leave provisions (neutral-to-bad, neutral-to-bad, A.13) Encouraging work from home (neutral, good, A.16)	Introducing or tightening renewable portfolio standards (neutral, good, A.14) Tightening air pollution regulations (good, good, A.15) Promoting active modes of transportation (good, good, A.17) Conditions on bailouts (neutral-to-good, neutral-to-good, A.18)

Table 1. A categorization of climate and corona policies, our main conclusions and references to appendix sections. Conclusions summarized as (evaluation for coronavirus, evaluation for climate).

Sector	Industries and evaluation
A	Agriculture, forestry, fisheries (neutral, bad)
B	Mining (neutral, bad), Fossil fuels (neutral, very bad)
C	Manufacturing (neutral-to-good, bad-to-neutral)
D	Electricity and heating (neutral, bad)
G	Wholesale and retail trade (neutral-to-good, neutral-to-good)
H	Transport and storage (neutral, bad), delivery (good-to-neutral, good-to-neutral)
I	Hotels and restaurants (good, neutral-to-good)
N	Rental, real estate services, travel services and other support (neutral-to-good, neutral)
P	Education (good, good)
Q	Healthcare and elder care (good, good)
R	Culture, entertainment and hobby (good, good)

Table 2. Evaluation of industry aid per sector. Please note that this is not an analysis of all sectors presented in the data section. We present here sectors for which we have conclusions to share. See details in Appendix A.2.

3.1 Evaluating policies

We have evaluated the set of policies in Table 2 and Table 3 (the latter breaks down financial assistance to firms by industry). Figure 3 summarizes the conclusions from this analysis. We plot policies according to how good they are for the coronavirus crisis (vertical axis) and for the climate crisis (horizontal axis). Policies marked green denote stimulus policies, policies marked red denote tax reform policies, and policies marked blue denote other cross cutting policies. Below we proceed to comment on policies we have identified as particularly promising (located in the upper right corner). A detailed analysis of these—and other policies—can be found in the appendix (A.3-A.18). There, after describing each policy and briefly analyzing it, we draw a conclusion as to how it scores in terms of alleviating the recession and its long-run climate impact. These scores take seven levels: very bad; bad; bad-to-neutral; neutral; neutral-to-good; good; very good (these results are also presented in Tables 2 and 3). The precise scoring can be refined, but we present a conceptual framework for analyzing the joint set of policies meant to address the coronavirus recession and climate crises.

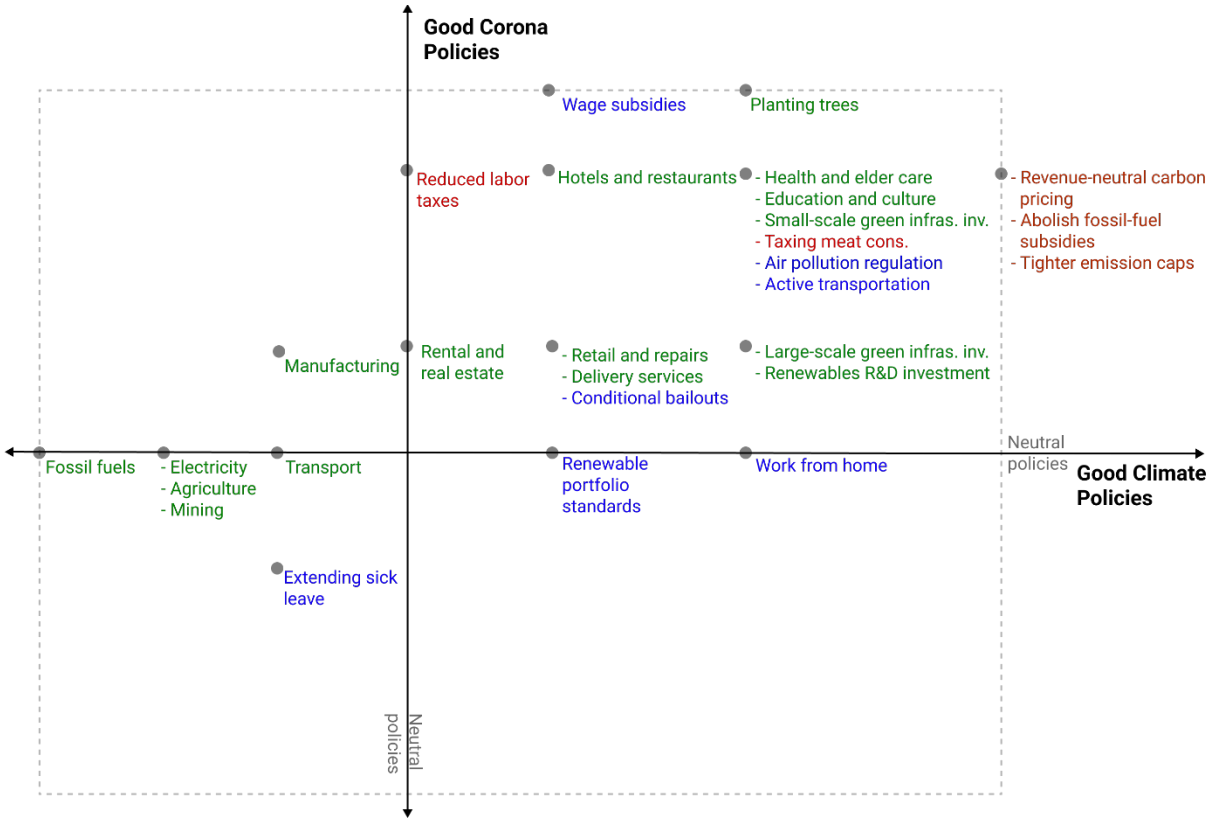


Figure 3. Summary of policy evaluation. Green: stimulus spending policies, red: tax reform policies, blue: cross-cutting policies.

3.1.1 Industry-based stimulus to protect employment and prevent bankruptcies

We plot these policies in green, labelled by industry. There have been various policy proposals on how to support businesses and workers, in general, during the crisis. These include giving out loans or grants to small businesses, or providing firms with tax relief (Becker et al., 2020; Scarpetta et al., 2020). These policies aim to support business owners, to support workers and allow them to maintain their relationship with the firm, or to prevent the overall collapse of businesses.

The choice between different industries appears the most consequential decision that governments can make. How the stimulus funds are allocated across industries determines both the short-run employment effects and could have long-run climate implications. The question we therefore ask is: which sectors should be targeted for aid (bailouts, investments, loans, etc.) if the objective is for this to both alleviate the current crisis and be good for the climate?

Whether stimulus for particular industries has meaningful impacts on long-term climate goals depends on several factors. For example, preferentially saving firms in a given sector may not have a large direct impact on the sector in the long run. The reason is that the capital assets, many of them specific to the sector, will still exist; so will a large fraction of the sector-specific human capital.

Thus, even if a wave of bankruptcies were to destroy many businesses in some low-emissions sector, that sector may spontaneously recover once the crisis has passed. One potential long-run effect from extensive bankruptcies in a sector is that consumers and buyers may shift their habits away from that sector, implying a long-run decline in sector-specific demand. Furthermore, persistent changes may result through the forced experimentation mechanism or long-lived government investments. Bankruptcies among firms conducting R&D into renewables may lead to a slowing of technological change (which we address separately below).

The political channel can also be at work. Firms will likely vary in their ability to weather the current crisis along many dimensions. If there is systematic variation in survival probability between firms in competing subsectors, long-term effects may result from subsectors that see many firms go bankrupt being unable to represent their interests in the political process. For example, in the European electricity sector, the largest firms tend to focus on fossil-fuel technologies in their innovation. Large firms also likely have better access to credit. Thus, a wave of bankruptcies may mean policies in the recovery stage may favor large, fossil-oriented firms. Such temporary disruption can have persistent effects, by strengthening the structure of vested interests in the sector, and thus the persistence of policy (Brainard and Verdier, 1994; Coate and Morris, 1999). This presents another reason for supporting vulnerable 'green' industries.

A word of caution is in place. Aiding industries has at least two problems. First, it may not be politically feasible. Second, it may not be very efficient in general compared to more direct measures at tackling unemployment. Funds to aid firm survival will help firms' owners without necessarily boosting employment. The same holds for tackling climate change. This is since such assistance would work only indirectly to affect the goals (such as employment and lower emissions) and firms may not use the aid as intended. A valuable complement could be conditioning of aid at the firm or industry level, for those who receive it. This policy is orthogonal to other policies but could ensure that industry aid becomes more effective, by aligning the recipient's goals with those of the policy-maker. For instance, assistance could be made conditional on lowering emissions or on the funds being used for hiring or retaining labor. Conditioning loans is common practice at the World Bank and IMF, and for many governments. There are several examples of such conditioning having already been used in the current crisis. For more details on contingent policies, see Section 3.1.4.

Based on this analysis, previous research and data of employment and emissions, the sectors **hotels and restaurants, health care** and **education** would be good candidates but for different reasons (for a results of the other sectors see Table 3; for a fuller analysis of all sectors see also Appendix A.2).

Restaurants are very labor intensive, have been hit hard by the lockdown and have low direct emissions. Targeting this sector in the recovery phase could therefore be a good idea. **Hotels** have also been severely affected, but subsidizing hotels likely aids the transport sector which is very emissions intensive. Hence, a finer targeting may be needed here, for instance, only towards

restaurants or more broadly to other service industries. We rank aiding this sector as good at alleviating the coronavirus crisis and neutral-to-good for the climate.

The **education** sector has not been hit by the crisis. But having a high labor share and being essential in the structural transformation of the economy forced by the coronavirus crisis, this sector is key in dealing with that crisis. At the same time, it is low on emissions. Stimulus may thus shift production and 'consumption' in a climate-friendly direction. We rank aiding this sector as good at alleviating the coronavirus crisis and good for the climate.

Health care also has high employment intensity. It of course has not seen any layoffs, being essential for dealing with the medical fallout of the current or future pandemics. It is also low on emissions, so the same motivation as for education applies here. We rank aiding this sector as good for alleviating the coronavirus crisis and good for the climate.

Economic stabilization can of course take the form of **monetary stimulus**. Relatedly, it has been suggested the fiscal commitments could be funded as 'helicopter money'—by printing money. We are not aware of research on the climate effects of such policies, so we do not include them in our ranking, summary and conclusions. See Appendix A.3 for further details.

3.1.2 Climate-oriented stimulus

These policies are also plotted in green. Fiscal stimulus can be aimed at 'climate-oriented' infrastructure investment such as renewable-energy generation facilities, associated infrastructure, and energy-saving investments. Governments have already announced very large investments in infrastructure as part of stimulus programs. On May 27th 2020, the European Commission presented a revamped long-term EU budget and a €1.85 trillion recovery plan, with the explicit goal to provide the instruments to build a modern, clean and healthy economy, better known as the 'EU Green Deal' (New Europe, 2020). Stimulus spending should be directed according to these plans if governments are serious about climate change mitigation. Not doing so will undermine the climate targets: recovery from the coronavirus crisis will exhaust the appetite for public spending for many years. But from a coronavirus perspective, the immediate benefit of such investment stimulus is unclear. The stimulus would primarily operate through the construction sector. However, this sector has not seen severe layoffs due to the health crisis. There is thus a trade-off between optimizing strategic investments that move societies onto more sustainable pathways, and getting societies out of the immediate coronavirus recession as rapidly as possible. If there is potential for sufficiently skilled workers to move in from other sectors, there could be beneficial short-run effects on overall employment.

The most direct long-term climate policy effect of green infrastructure investments is their emissions reduction throughout their long lifetimes. Complementarities (for example due to network infrastructure investments) mean they can also spur further, private investment, and shift societies

away from 'carbon lock-in' and towards a 'green lock-in' path. This lock-in can be reinforced by indirect channels. A shift towards green investment generates larger vested interests in favor of e.g. carbon pricing policies, given that renewable investments stand to gain from such policies. For example, in Germany, the feed-in tariffs for renewables generated constituencies and advocacy groups which stabilized the policy regime and led to an expansion of the sector (Jacobsson and Lauber, 2006; Strunz et al., 2016). Further, any shift towards greener infrastructure and future pricing policies incentivizes green R&D investments, due to larger potential market size (Acemoglu et al., 2012). The channels involved here are thus long-lived investment, changing political status quo and technological changes.

An important point here is that the labor intensity of infrastructure projects depends on their scale: small-scale projects are more labor-intensive than large-scale projects (Strand and Toman, 2010). This could favor small-scale renewables such as residential solar and retrofit projects. Our judgment of the effect on coronavirus crisis is therefore based on the scale of the projects.[4] Based on the above, we particularly want to highlight **small-scale infrastructure projects** such as retrofitting insulation and installing solar panels on houses. We rank this policy as good at alleviating the coronavirus crisis and good for the climate.

For reasons similar to those in the case of large-scale infrastructure investment, we do not think that **extensive green R&D investment**, while good for climate, will be particularly well-suited to deal with the coronavirus crisis as the effects on employment in the short-to-medium run are essentially limited to those holding the right competence. Investing in green R&D will just shift research labor from one area to another. **Fiscal stimulus to private R&D spending** in the renewable energy sector, by way of grants or loans, can prevent bankruptcies and the breaking up of successful R&D teams. More details can be found in Appendix A.5. We rank both policies as neutral-to-good at alleviating the coronavirus crisis and good for the climate.

Another promising green stimulus option is **planting trees.** Afforestation and reforestation activities are likely cost-effective both in terms of climate and in terms of the coronavirus crisis, as the trees will absorb CO_2 and as planting requires large numbers of manual and unskilled labor (Strand and Toman, 2010). We rank this policy as good at alleviating the coronavirus crisis and good for the climate (see more in Appendix A.6).

3.1.3 Green tax reform

We plot these policies in red. While tax reforms obviously do not need to be climate-motivated, we have identified **revenue-neutral 'green tax reform'** (involving for example carbon taxes, an abolition of fossil fuel subsidies, tighter emission caps, and meat consumption taxes) as especially

[4] For instance, Demetriades and Mamuneas (2000) show that regular infrastructure projects give low returns in the short run but high returns in the long run. Hence, for boosting employment under the corona crisis it is not very useful. See also Morrison and Schwartz (1992).

promising, because it would enable an even more aggressive stimulus package (see Appendices A.8-A.10).

Revenue-neutral policies not only have important long-run climate effects, but also have the potential to improve economic recovery. Green taxes improve economic efficiency by internalizing the carbon externality. How the revenues are spent determines which industries and consumers are winners vs. losers (and thus whether the policy is on net favorable or unfavorable to preserve employment). There is a possibility of a double dividend if the revenues are used to offset pre-existing distortionary taxes (Goulder, 1995; De Mooij, 1999). The coronavirus recession may thus be a politically opportune moment for well-designed green tax reform that enables environmental and employment benefits at the same time.[5] We rank **carbon taxes**, an **abolition of fossil fuel subsidies** and **tighter emission caps** as good at alleviating the coronavirus crisis and very good for the climate. We rank a **meat consumption tax** as good at alleviating the coronavirus crisis and good for the climate.

As a benchmark for the neutrality of the green taxes, we assume that the proceeds are spent on reducing labor taxes. One reason for using this benchmark is that fiscal stimulus in the form of reduced labor taxes takes effect more quickly than monetary stimulus (Kaplan and Violante, 2014). This could be good for a rapid exit from the coronavirus crisis by stimulating labor demand. Such tax cuts can also be tailored with distributional impacts in mind, and could thus be designed to help households most likely at risk of an immediate liquidity crisis. To use the proceeds for labor tax reductions is of course just one option out of many.

A green tax reform would have an even more favorable impact on the climate if the revenues were spent on direct investments in renewable energy, clean tech R&D, and other low-carbon technologies. In this case, both the tax itself and the revenues provide immediate incentives to reduce emissions, while also benefiting from path-dependency effects of redirecting capital to build up a greener capital stock. This type of revenue recycling is less attractive from the perspective of mitigating the recession, as many green investments do not require much labor.[6] We would therefore focus on policies that reduce labor taxes economy-wide.

Labor tax cuts are a form of fiscal stimulus which could be considered in isolation for tackling the coronavirus fallout. We are not aware of research that would shed light on the impact of labor tax reductions, in isolation, on climate outcomes. We rank this policy as good for the coronavirus crisis and neutral for climate. See Appendix A.7 for further details.

[5] The interaction with pre-existing taxes can still lead to a positive cost of a revenue-neutral carbon tax (Bovenberg and Goulder, 1996). The double dividend remains an open question in the general equilibrium literature, with half of simulations achieving negative-cost environmental taxation (Freire-González, 2018).

[6] Another common carbon tax proposal distributes revenues as lump-sum transfers to households ('tax-and-dividend'), such as Canada's national carbon tax and several legislative proposals in the United States (Sobczyk, 2018; Nuccitelli, 2018).

3.1.4 Other promising cross-cutting policies

We plot the cross-cutting policies in blue. The pandemic has led many governments to impose different forms of regulations and restrictions on citizens and businesses, related for example to travel, sick leave, and way of doing business. There are also mandates that have been, or could be, imposed with the primary purpose to mitigate emissions and air pollution. These are relevant to analyze as they in turn may impact economic recovery, or adaptation potential for the current or future pandemics. We comment on the most promising of such policies here.

Neves and Brand (2019) find that about 41% of short car trips could in theory be replaced by cycling or walking, reducing emissions from car travel by about 5%. City planning policies and infrastructure investments **promote active modes of transportation** by making car travel more expensive (e.g., congestion charging) and less convenient (Winters et al., 2011). We already see initiatives along these lines. Milan plans to reallocate 35 kilometers of street space from cars to cycling and walking in the summer of 2020, in response to the coronavirus crisis. Given path dependencies of infrastructure investment and forced experimentation, initiatives like this can also foster persistent change. A shift towards active modes of transportation could also have long-run health effects in the form of lower rates of obesity, diabetes, and hypertension (Pucher et al., 2010; Rasmussen et al., 2016; Grøntved et al., 2016). This reduces the share of people vulnerable to the coronavirus. We rank this policy as good at alleviating the coronavirus crisis and good for the climate.

Tighter air pollution regulation would reduce carbon emissions: this could involve switching from coal generation to gas generation, especially near population centers, and boosting less emission-intensive transport. Such policies may involve long-lived investments (into renewables and gas-fired plants to replace coal) which will be long-lasting. They will also generate new interest groups (cyclists, drivers of electric vehicles) and perhaps reduce the power of coal generators. There is also some preliminary evidence that local air pollutants, such as nitrogen oxides (NO_x) and atmospheric particulate matter with a diameter of less than 2.5 micrometers ($PM_{2.5}$) may increase mortality from the coronavirus (Ogen et al. 2020; Wu et al. 2020). If these preliminary findings hold up, they point to long-term benefits if the virus becomes endemic, circulating in the population indefinitely.[7] We rank this policy as good at alleviating the coronavirus crisis and good for the climate.

There has been a broad debate about **conditioning bailouts** to firms in polluting sectors. If a bailout can be credibly conditioned on future changes in activity, and if, in the absence of bailouts, the industry is likely to resurrect after any bankruptcies, then conditional bailouts of emission-intensive sectors may be beneficial to the climate. Consider airlines: a wave of bankruptcies will wipe

[7] Parry et al. (2014) estimate the co-benefits associated with a reduction of local air pollutants would already be substantial just for a reduction of coal burning—the co-benefits alone would justify a U.S. carbon price of $\$35/tCO_2$, of which 30% is due to NO_x and $PM_{2.5}$ emissions. Higher coronavirus mortality rates would increase such co-benefits.

out current shareholders, but the aircraft assets will be sold to new companies once the health crisis subsides, and these new firms will operate according to market incentives. A bailout will save the current firms, but it can set conditions on their future behavior, such as reducing the number of short-haul flights for which feasible low-emission alternatives exist. Several airlines have already been given bailout loans with no conditions attached (Laville, 2020). On the other hand, the bailout given to Air France comes with the requirement that the company halve its carbon emissions from domestic routes, essentially forcing it to cut back services on routes (Financial Times, 2020). We rank this policy as neutral-to-good at alleviating the coronavirus crisis and neutral-to-good for the climate.

Recapitalization is an alternative to conditional bailouts. Rescuing firms by injections of equity using public funds are, effectively, partial nationalizations. As such, they give the state an ownership stake in the firm, and thus a voice in the management of the firm. Many commentators warn against the state taking a role in commercial decisions, even in situations in which it does hold a stake. However, where a firm's commercial decisions involve important externalities, it may be justifiable to have the state exercise its owner's right to influence commercial decisions, so as to take account of the full social costs of these decisions. The recapitalization should be large enough to give a state a voice as a major shareholder. The channels involved here are thus through long-lived investment and political status quo.

Government may **pay wages for private employees** as a way to avoid the labor search costs associated with rehiring once the economy starts to recover (as proposed by Sinn, 2020). With regards to the long-term climate effects from this policy the results are less clear. If labor gets increasingly replaced by capital as a result of forced experimentation, where companies adopt new technologies or management practices that replace some of the previous jobs, this shift in the capital-labor share could potentially have a negative climate impact since capital is typically more fossil fuel intensive. The specific impacts may depend on industry; the analysis of Section 3.1.1 applies. We conclude that his policy is very good for addressing the coronavirus crisis and neutral-to-good in terms of climate.

In this category we have also looked into **tightening renewable portfolio standards**, and **encouraging working from home**. We have ranked these policies as neutral for alleviating the coronavirus crisis and good for climate (the analysis is found in A.14 and A16 respectively).

A cross-cutting policy that is not promising though is **extending sick leave provisions** (see Appendix A.13). Unless also financed by the government, such provisions may lead to bankruptcies and substitution away from labor. We rank this policy as neutral-to-bad for alleviating the coronavirus crisis and neutral-to-bad for climate.

4 Concluding remarks

The severity and abruptness of the coronavirus crisis do not make the climate crisis any less pressing. Our societies need to solve the former, immediate crisis without taking our eye off the latter, inexorable one. We have above identified a set of policies that would help in tackling both the coronavirus crisis and climate change.

The most effective policies involve revenue-neutral tax reforms towards carbon pricing, which would be excellent climate policies and also help deal with the coronavirus crisis by allowing reductions to labor taxes. Subsidizing temporary employment in less emissions-intensive industries (services sectors including leisure services like restaurants and culture; or professional services like technology, education, and healthcare) can help laid-off workers try out occupations that have potential even under tougher climate policies. Labor-intensive investments into natural capital (tree planting) and into low-carbon physical capital can both support employment and incomes, while storing carbon or helping societies transition towards a low-carbon future. Health and climate goals can also be achieved by promoting transport methods which not only reduce carbon emissions, but local pollutants too, improving cardiovascular health. All sectoral aid should be conditioned on being directed towards employment and on low-carbon supply chains.

The crisis is ongoing, and the full outcomes in terms of health and unemployment are yet to be known. Policies will be tried out, and their effects will be observed. Thus, our results may require revision as more information becomes available. Nevertheless, our approach provides a conceptual framework for how to jointly assess the medium-run effects of policies on the coronavirus crisis and the long-run effects on the climate crisis. Both are severe and neither can be ignored. Fortunately, modern societies should be capable enough to walk and chew gum at the same time.

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A. Appendix (online only)

A.1 Additional data

In this section, we show unemployment claims in the United States by sector, for the period March 14th - May 2nd, 2020, in Figure A1. Figure A2 shows that layoffs are strongly correlated in the United States, Sweden and Finland. As a complement to Andersen et al. (2020) and Carvalho et al. (2020), Figure A3 shows production growth across sectors for the period March 1st-April 28th, 2020, illustrating that sectors that have seen large declines are also roughly those that have seen large numbers of layoffs. It should be noted that the data are preliminary and incomplete. Some sectors are missing (e.g. A) while others only have data for March (R and S). Finally, the figure adds the growth rates for March and April (rather than treating it as compound growth). For these reasons one has to interpret the precise numbers with caution. The main point here is that sectors that have seen large declines are also roughly those that have seen large layoffs.

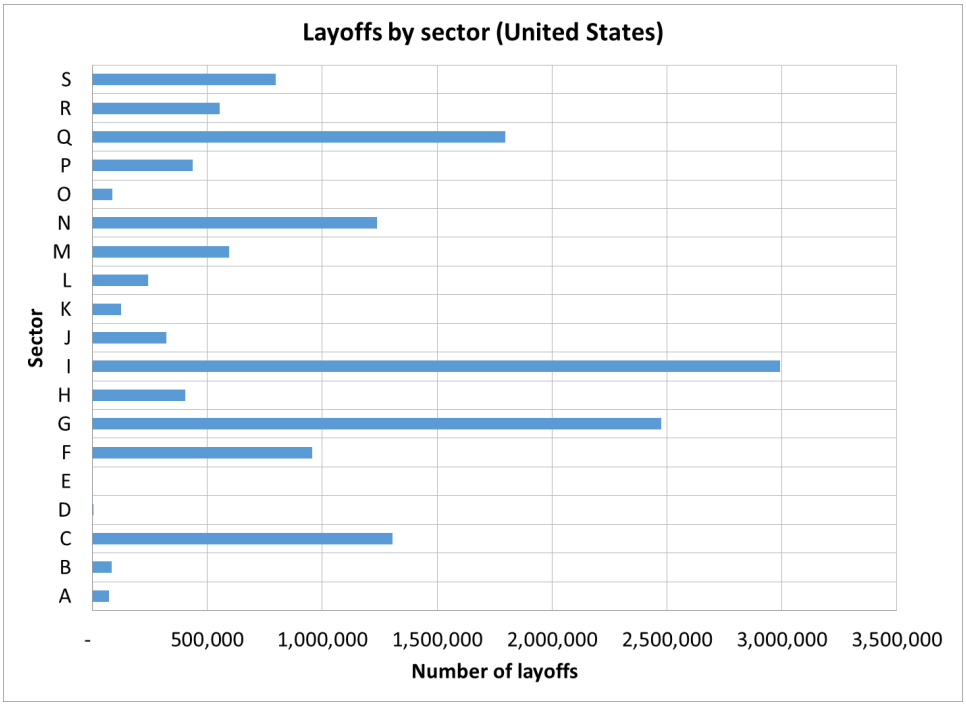

Figure A1. Layoffs by sector in the United States.

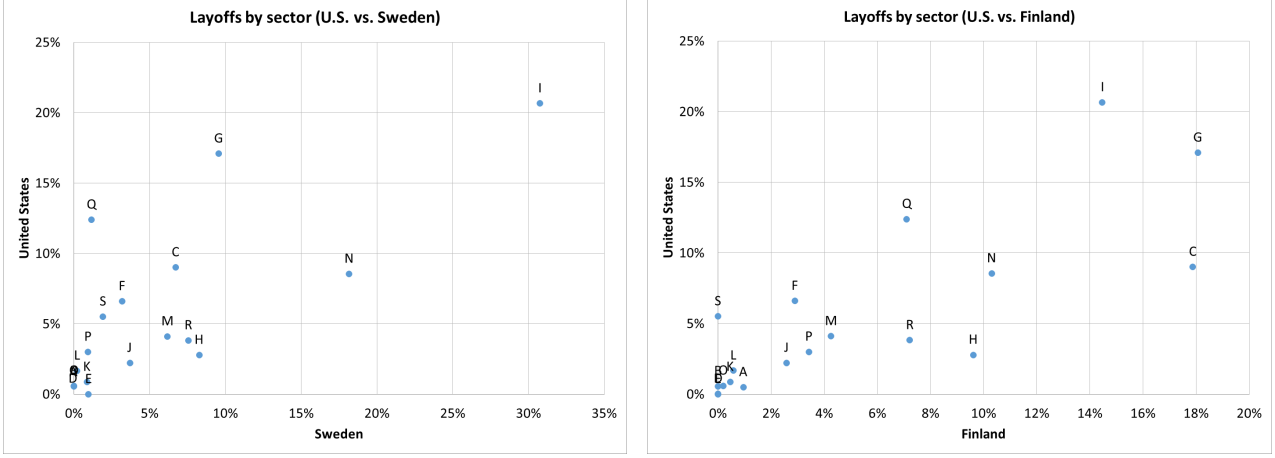

Figure A2. Layoffs by sector in the United States vs. Sweden (Panel A) and Finland (Panel B).

Panel A: United States vs. Sweden Panel B: United States vs. Finland

Notes: Source: weekly initial unemployment claims by state and industry from the Economic Policy Institute. Available at https://economic.github.io/ui_state_detailed/. Sector definition in Table 2. Data are normalized as percentages of total unemployment claims.

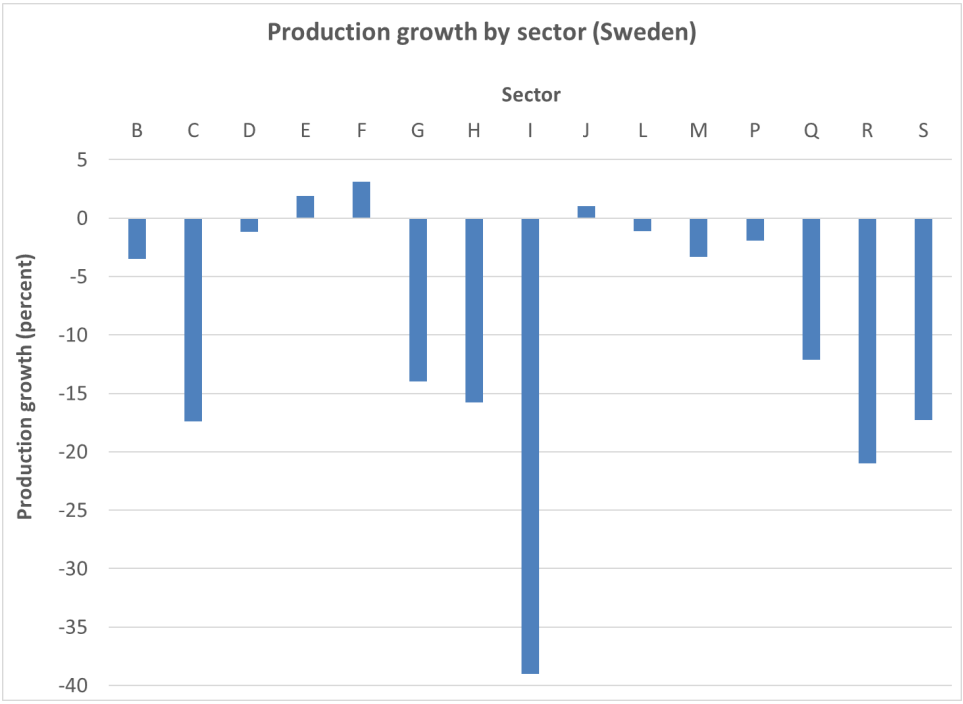

Figure A3. Production growth by sector in Sweden during March and April 2020.

Notes: The data are seasonally adjusted and normalized by length of months. Sector definition in Table 2. Some sectors are missing (e.g., A) while others only have data for March (R and S). Finally, the figure adds the growth rates for March and April (rather than treating it as compound growth). Data from Statistics Sweden. Available at https://www.scb.se/hitta-statistik/statistik-efter-amne/naringsverksamhet/amnesovergripande-statistik/produktionsvardeindex/

A.2 More detailed industry analysis

Hotels and restaurants

The one sector that stands out the most is hotels and restaurants. It has seen massive layoffs while also having very high labor shares and low emission levels. Helping this industry will be **good for the coronavirus crisis.** In terms of climate the picture is more mixed. On the one hand, the industry has low indirect emissions. Hence, if avoided supply disruptions/bankruptcies ensure that the long-run demand does not shift away from this industry in the medium to long run this would be good for the climate. Yet, the hotel industry is closely linked to the travel industry which has very high emissions. Hence, we categorize it as **neutral-to-good for climate change**.

Retail, wholesale, repairs of vehicles

This industry has also seen large layoffs though it does not score very high in terms of general labor intensity. It has a reasonably low emissions intensity. Furthermore, this industry is key in recycling as it ensures that vehicles (whose production is generally emission intensive) are not scrapped early. Helping this industry is therefore categorized as **neutral-to-good for corona and neutral-to-good for fighting climate change**.

Rental and real estate

This sector has seen high layoff numbers but is not particularly labor intensive. We therefore conclude that **from a corona perspective it is neutral-to-good**. It has quite high emissions so we categorize it as **neutral in terms of climate**.

Manufacturing

The manufacturing sector has seen large layoffs but this is probably due to its size. It has a rather low labor intensity so saving jobs in this sector (by bailing it out) will be a costly prospect. We therefore categorize it as **neutral-to-good in terms of the coronavirus crisis**. The manufacturing sector has relatively high emissions per value added. So we categorize it as **bad-to-neutral in terms of climate**.

Healthcare and elder care

Healthcare contributes about 4-8% of the carbon footprint in most countries (Pichler et al., 2019). In the U.S. and Sweden, it contributes 7.9% and 4.5% respectively. Emissions per employee is lower in the health care sector than for the economy as a whole. Hence, the health care sector is labor

intensive but, naturally, has not seen large layoffs during the current crisis.[8] It has low emissions. Obviously, investing more in health care and elder care is necessary in the short run to fight the pandemic and may also, by salience and risk awareness shifting preferences, have an effect in the long run. Thus, being high in labor and low in emissions, stimulus and aid of health-care have a good stimulating effect on the economy and reduce emissions in the long run. We therefore categorize it as **good for corona and good for climate**.

Education

The education sector has not seen large layoffs (not surprisingly being public enterprises in many countries) but is highly labor intensive. As such it does not need help per se. However, under the coronavirus crisis, retraining of labor to new tasks may be essential in the short to medium run—away from jobs in low demand to jobs in very high demand (like health care). The education sector is key in this transformation so investing in it is important for handling the coronavirus crisis. The sector is low in emissions. Hence, we categorize investment in this sector as **good for corona and good for climate**.

One specific policy would be to subsidize training programs for particular skills associated with jobs in these low emission sectors (OECD, 2012). Governments could also offer more beneficial student loans and/or help universities to increase the number of enrolled students for particular types of training and education programs, and as a way to invest in overall human capital (Spiro et al., 2020).

Another potential measure, spanning more than this sector, is to offer governmentally subsidized 'internships' in low emission sectors, e.g. at daycares, schools, elder care homes, and restaurants. This would be a way to also reduce unemployment among young people, for whom entry to the labor market is now more challenging than usual.

Culture

This sector has not seen large layoffs in terms of numbers, but being a small sector, this hides the actual effect. It is also very labor intensive. Hence, aiding this sector will have high returns on investment for fighting the coronavirus crisis. It also has low emissions. Hence, we categorize investment in this sector as **good for corona and good for climate**.

Transport and delivery

The transport industry has been hit extremely hard by the crisis—in particular airlines, for which demand has plummeted to close to zero. However, transport in general and airlines in particular are not particularly labor intensive and have high emissions intensity. Hence, aiding this industry does not help keep up demand and employment and will be harmful for the climate by the following

[8] In the U.S. the sector has seen rather large layoffs. This does not change our conclusion.

reasoning: It is unclear to what extent they will be resurrected automatically in the long run. To the extent that they will, they do not need to be bailed out. If they are not resurrected in their own right this will be due to shifts in habits and consumption priorities among consumers. Hence, spending money on transport and airlines will at best have no effect on the climate with **neutral on the coronavirus crisis** or **have a bad effect on the climate in the long run**.

We add two caveats for this conclusion. First, if coupled with conditions, aiding the transport industry may not be harmful for the climate. See further discussion in section 3.1.4 on conditional aid. Second, the transport industry is heterogeneous. Some of it could be beneficial to stimulate. For instance, an expanding delivery service sector has the potential to increase employment since otherwise unpaid work (carried out by consumers) would be turned into employment.[9]

A rough estimate of U.S. emissions from driving to buy groceries is 17 million metric tons of CO_2 per year, or about 0.2% of total U.S. emissions (U.S. EPA, 2016). The benefits, in terms of emissions, of replacing individual trips to the store by delivery services depend on a multitude of factors. Deliveries will cause less emissions if the delivery service has a sufficient number of customers, the delivery times are sufficiently flexible to allow for route optimization and the delivery trucks are sufficiently fuel efficient compared to the average car (Brown and Guiffrida, 2014; Hardi and Wagner, 2019).

There are also benefits during the current pandemic. Delivery services replacing individual trips to stores significantly reduces the number of people coming into contact with each other and thus prevents disease spreading.

We therefore categorize **delivery services as neutral-to-good for corona and neutral-to-good for climate.**

Mining and fossil fuels

The oil sector has been hit hard, as demand for transportation has plummeted and oil prices briefly became negative during April 2020 (Dezember, 2020). As a result, the United States is planning for a bond bailout program that includes oil producers and coal-heavy companies (Harvey, 2020).

While losses in the fossil-fuel sector have been sharp, the incidence likely falls on landowners and corporate shareholders, as many of these sectors are not particularly labor-intensive (see Figure 2). It

[9] U.S. employment in the category 'Couriers and Messengers' was in April 2020 847,000 and has been more or less constant since February 2020 (it decreased somewhat from January to February). Overall U.S. (nonfarm) employment has during the same period decreased from 152,000,000 to 131,000,000. Employment in the category 'Couriers and Messengers' has increased significantly since 2010. Currently the sector employs about 0.6% of all employees (up from about 0.4% in January 2010). It seems likely that the pool of potential employees has a relatively large overlap with many of the jobs lost in the service sector. Hence there should be some potential for an expanding delivery services sector to have benefits in battling the unemployment caused by the pandemic.

is also likely to reduce economic surplus because the sector is increasingly seen as high-risk for 'stranded assets,' as many institutional investors have pointed out. For example, Blackrock—the world's largest fund manager— had divested from coal (Partridge, 2020).

A fossil fuel bailout will keep the most carbon-intensive industries alive and decelerate investments in the green economy, with the associated costs of path-dependence. Path-dependence could also operate through lobbying power, R&D, and human capital. The oil sector has experienced boom-and-bust cycles before, but in the current environment the rapid downsizing of investments and jobs can erode its long-run lobbying power and regulatory capture, reduce R&D for fossil fuel production, and stop the inflow of talent into fossil fuel companies. For all these reasons, a fossil fuel bailout is very damaging from a climate perspective.

The fossil-fuel industry, just like the mining industry in general, has a very low labor intensity. Hence, if not harmful, spending money on it is an expensive way of creating employment. Furthermore, since there is no shortage of oil (in fact, there is oversupply) there is no need to resurrect it to keep other industries alive.

We therefore categorize **the corona effect of the fossil-fuel industry as neutral and the climate effect as very bad.**

The mining industry has not been hit as badly as the fossil-fuel industry. It has low labor intensity and high emission intensity. We therefore categorize the mining industry as **neutral in terms of corona and bad in terms of climate.**

Electricity and agriculture

Some industries, like electricity and agriculture, have not been hit particularly hard by the crisis. Furthermore, they are generally quite emission intensive (for electricity this varies between countries). Aiding electricity does not help keep up demand and employment and will be harmful for the climate. Hence, spending money on electricity will have **a neutral effect on the coronavirus crisis and a bad effect on the climate in the long run.**

For agriculture, the picture is more mixed. While it has not experienced high layoffs, its labor intensity varies substantially between countries. Some parts of the agricultural industry are rather labor intensive, in particular in low-skilled workers. However, since agriculture has seen large demand increases, it does not need stimulus. Instead what may be useful is retraining of labor from other sectors. We therefore categorize it as having **a neutral effect on the coronavirus crisis and a bad effect on the climate in the long run.**

A.3 Helicopter money, monetary stimulus and other redistribution policies

The magnitude of the coronavirus crisis implies a need for very large quantities of government spending. The conventional way to fund such spending is to issue government debt. However, many governments are saddled with high debt-to-GDP ratios, and raising more money on the markets can threaten their perceived solvency, potentially even leading to runs on sovereign debt.
One suggested solution involves 'helicopter money': the financing of stimulus transfers by the central bank printing money, i.e. monetizing the associated debt (Blanchard and Pisani-Ferry, 2020; Gali, 2020; Kapoor and Buiter, 2020; Yashiv, 2020). Unlike the canonical indiscriminate helicopter drop intended to move an economy off the zero lower bound, for instance by a lump-sum transfer to citizens or to taxpayers, the current crisis calls for targeted transfers. Given the unique nature of the coronavirus crisis, such a policy can be credibly argued to be an exceptional, one-off event, which does not need to impact the credibility of the central bank's inflation target.

As long as the quantities involved are sufficiently large, such a policy can give governments fiscal space to tackle the impacts of the crisis, and thus the policy can be effective in fighting the coronavirus crisis. However, in the eurozone, the monetization of member state government debt is a politically touchy issue (Yashiv, 2020) and thus any program of mutualizing risks should arguably be conducted transparently, via explicit fiscal transfers or mutualized debt (Blanchard and Pisani-Ferry, 2020).

Monetizing the debt required for stimulus spending is closely connected with the allocation of the cost of tackling the coronavirus crisis (Masciandaro, 2020). It will affect how the burden is shared between generations, between countries (e.g., in the eurozone, or between debtor and creditor countries), and between groups in the society (such as taxpayers or savers). It will thus affect the distribution of income, wealth across time and space, as well as the path of future economic distortions (due to tax wedges, costs of inflation, etc.). These effects are unlikely to be neutral vis-a-vis long-run climate policy. However, we feel these very indirect effects are currently unknowable, and are not aware of any research that would illuminate such effects.

Short of the central bank's involvement, these points hold roughly also for other types of redistribution such as increased child allowances.

Apart from helicopter money, central banks of course have access to conventional and unconventional policies for monetary stimulus. We are not aware of any research on the climate effects of monetary policy. Since we do not know the effect on the climate we do not include such policies in our summary and conclusions (the coronavirus impacts would depend on the exact policy and context).

A4. Green infrastructure investment

The immediate unemployment impacts of the pandemic, and the medium-term impacts of the subsequent recession, could be tackled by fiscal stimulus aimed at 'green' infrastructure investment: renewable-energy generation facilities, associated infrastructure, and energy-saving investments.

Governments have already been announcing very large investments in infrastructure as part of their stimulus programs (New Europe, 2020). Following the coronavirus stimulus, public debt stocks will be substantially higher, making it unlikely there will be appetite for a further round of 'green' public investment in the near future. From a coronavirus perspective, the immediate benefit of such investment stimulus is unclear. The stimulus would primarily operate through the construction sector, but this sector has not seen severe layoffs due to the health crisis. To the extent that there is potential for sufficiently skilled workers to move in from other sectors, there can also be beneficial short-run effects on overall layoffs.

The labor intensity of infrastructure projects depends on their scale: small-scale projects are more labor-intensive than large-scale projects (Strand and Toman, 2010). This could favor small-scale renewables such as residential solar and retrofit projects. Our judgment of the effect on coronavirus crisis is therefore based on the scale of the projects.[10]

The most direct long-term climate policy effect of green infrastructure investment is their emissions reduction throughout their long lifetimes. Complementarities (for example due to network infrastructure investments) mean they can also spur further, private investment, and shift societies away from 'carbon lock-in' and towards a 'green lock-in' path.

Based on the above, we conclude on a few potential policies. **Retrofitting insulation and subsidizing/investing in solar panels on private houses is good for corona and good for climate. Subsidizing/investing in electric vehicles, charging stations, utility-scale solar, and wind farms is neutral-to-good for corona and good for climate.**

A.5 Renewables R&D investment

R&D investments into renewable energy can boost the long-run viability of climate-friendly energy technologies (Acemoglu et al., 2012). Thus, direct R&D investments, or subsidies to private R&D investments, can both employ workers in the short run and help achieve long-run climate goals.

Whether fiscal stimulus to R&D spending is an effective tool for mitigating the consequences of the coronavirus crisis depends on how severely energy-sector R&D work has been affected. Some tasks

[10] For instance, Demetriades and Mamuneas (2000) show that regular infrastructure projects give low returns in the short run but high returns in the long run. Hence, for boosting employment under the corona crisis it is not very useful. See also Morrison and Schwartz (1992).

in this field will be suitable for teleworking, but others will require physical presence at laboratories and collaboration with colleagues. One option is to subsidize large pilot projects. The stimulatory benefits of such projects are similar to other projects in renewables infrastructure investment.

Of course, a weakened economic environment may push some firms into bankruptcy. R&D work is often associated with team-specific human capital. Bankruptcies, by breaking up successful R&D teams, tend to reduce patenting activity (Baghai et al., 2018). Thus it may be particularly useful to ensure the continued viability of firms working on innovation in the renewables sector by way of extending grants or loans to them while the crisis lasts.

The channels involved are political and technological. **We categorize the corona effect as neutral-to-good and the climate effect as good.**

A.6 Planting trees and maintaining national parks

Initiatives such as these would have an immediate effect on employment because they are labor intensive (Strand and Toman, 2010, document the high employment impact per spending in Korea during the Great Recession), the jobs do not require specific skills, and the projects require little planning. Such policies can also have substantial effects on the climate. Take reforestation projects for example. As trees grow, they absorb and store carbon dioxide emissions. According to Bastin et al. (2019) there is globally the potential for 0.9 billion hectares of additional forest cover (when excluding urban areas and land currently used for agriculture). Reforesting all this land could store 25% of the current atmospheric carbon pool. Contributing to such reforestation also seems to be a politically feasible.[11] **We categorize the corona effect as very good and the climate effect as good.**

A.7 Reduced labor taxes

We first consider reductions in labor taxes that are not revenue-neutral. There has been a wide debate on the fiscal multipliers associated with tax cuts, as recently surveyed by Ramey (2011; 2019). The evidence on estimated effects is inconsistent and depends on the method of estimation; lowering of labor taxes may be only mildly stimulative (with multipliers well below unity in absolute value) or very stimulative (with multipliers between 2 and 3 in absolute value).

The particular features of the current crisis will affect how effective tax cuts are. First, the magnitude of the crisis is unparalleled: with unemployment rates in the tens of percent, recovery from the corona crisis is uncharted territory. As the immediate crisis lets up, many unemployed will likely be looking for any work, without worrying too much about marginal tax rates. Tax cuts may be more

[11] It even has the support of Donald Trump and U.S. Republican representatives: https://www.google.com/amp/s/reason.com/2020/02/13/republican-lawmakers-introduce-trillion-trees-act-to-combat-climate-change/%3famp

effective during times of low unemployment (Ramey, 2019). However, lower rates may boost employment as the recovery matures. Second, the layoffs have been concentrated among low-income groups. There is evidence that tax cuts for low earners can be particularly effective in stimulating economic activity (Zidar, 2019). Thus, the heterogeneity among wage-earners should be considered when designing stimulus policies based on tax cuts.

We are not aware of research that would shed light on the impact of labor tax reductions, in isolation, on climate outcomes. Therefore, we classify this policy as neutral on climate. **We categorize revenue-neutral labor-tax reform as good for corona and neutral for climate.**

A.8 Revenue-neutral carbon pricing

Imposing a carbon tax will have a number of effects related to the coronavirus crisis, depending on whether one considers the short or long run. One short-run effect is that it increases the price of one input, energy, which most likely has high complementarity with other inputs such as labor (Hassler et al., 2012). This would suggest a carbon tax could be damaging. At the same time, at least some empirical evidence suggests the effects on employment are small if they exist (Martin et al., 2007). Another mitigating factor is that fossil-fuel prices are now at a very low level so, in the short run, increasing the price would not damage economic activity (as noted in the industry analysis in section A.2, the fossil-fuel and energy industries do not by themselves employ much labor).

Another concern could be that carbon taxes could lead to relocation of production to areas with laxer environmental standards—the pollution haven effect. The evidence for this channel is mixed (Eskeland and Harrison, 2002; List et al., 2004). In the long run, whereby input mixes are more flexible, increased carbon taxes most probably shift production towards other inputs such as labor. We conclude that the direct effect of a carbon tax on the coronavirus crisis is ambiguous.

Most importantly, however, this is no longer the case if the carbon-tax reform is revenue neutral. The incidence of the carbon tax depends on how the revenues are recycled. If used to reduce labor taxes, the policy would shift the burden of taxation from labor supply to heavy carbon emitters, although it is not clear that the set of optimal or even second-best taxes features substantially lowered labor taxation (Barrage, 2019). Azevedo et al. (2020) find that British Columbia's revenue-neutral carbon tax that reduced other personal and business taxes benefited consumers, small businesses in the services sector, but hurt energy-intensive industries.

We therefore conclude that, whatever the adverse effects of a carbon tax may be on employment, they are very likely overshadowed by the effects of the lowered labor tax that this would enable. As for the climate effects, carbon taxation (and more generally carbon pricing) is largely considered as the first-best policy for fighting climate change.

This point needs no further elaboration. **Based on this we categorize revenue-neutral carbon-tax reform as good for corona and very good for climate.**

A.9 Abolishing fossil fuel subsidies

Subsidies to fossil fuel producers or consumers are prevalent in many countries. Producer subsidies commonly take the form of favorable tax treatment. Consumption subsidies lower the price of fossil fuels, or of fossil-fuel based electricity, to end-consumers, with the aim of aiding affordability. The International Energy Agency estimates that governments spent over $400 billion on consumption subsidies alone in 2018 (Matsumura and Adam, 2019); the implicit subsidy relative to efficient pricing is even much larger (6.5% of global GDP; see Coady et al. (2019)). Davis (2017) estimates the external costs at $44 billion annually. While these subsidies have proven persistent, the current low oil prices may provide a window of opportunity for net importers of fossil fuels to cut subsidies (or implement a carbon tax).

The direct effect on corona is that it reduces buying power. But fuel subsidies are regressive (Fattouh and El-Katiri, 2013), so a reduction in them coupled with reduced labor taxes will increase consumption and thus stimulate demand.

Fossil fuel subsidies can be seen as a negative carbon tax. Hence the same conclusions as above apply: **we categorize abolished fossil-fuel subsidies as good for corona and very good for climate.**

A.10 Taxing meat consumption

Livestock products alone are responsible for about 15 percent of global GHG emissions (Gerber et al., 2013). Consumption taxes on meat have gained an increased interest recently as a way to reduce GHG emissions associated with meat production, which includes direct GHG emissions from cattle ranching as well as from land-use change (deforestation).[12] Simulation studies show that a Pigouvian tax on meat can reduce emissions from food consumption by around 10 percent (Springmann et al., 2017; Säll and Gren, 2015).

We consider a revenue-neutral meat tax. An interesting alternative to lowering labor taxes would here be spending the revenues subsidizing/promoting vegetarianism by subsidizing plant based protein consumption or production, which would have a substantial effect on land use.[13] Hence the climate benefits of promoting plant based diets could be substantial. These benefits could also be

[12] One argument for a meat tax is that GHG emissions reductions from meat production are unlikely to happen from improvements in productivity alone (Bajzelj et al., 2014). Also, global demand for meat shows an increasing trend driven by higher living standards and urbanization (Xiong et al., 2020).

[13] A meta study by Aleksandrowicz et al. (2016) finds that shifting from the average diet to a vegetarian one would reduce required land use by 51%.

long-lasting, as the agricultural production systems change and innovate (path dependence) and people learn to prepare and enjoy vegetarian meals (habit formation).

We also note a long-term medical benefit from reduced meat consumption. Pandemics usually begin as outbreaks of Emergent Infectious Disease (EID) caused by animal pathogens from wildlife and livestock that spill over into people (Pike et al., 2014). The likelihood of such spillovers is increasing with land use changes, such as deforestation, agricultural development and urbanization (Gottdenker et al., 2014). Reduced livestock production and associated land use change could therefore significantly reduce the risk of future EIDs and be a viable strategy (Pike et al., 2014). Also, vegetarian diets are often healthier than meat based diets and hence could lead to an overall healthier population with less risk factors for severe complications from disease (Dinu et al., 2017).[14] **We categorize meat taxes a good for corona and good for climate.**

A.11 Tax reform through (tighter) emissions caps

Rather than taxing carbon, governments could implement a cap-and-trade market, or tighten the cap in an existing trading system. To a first approximation, the long-run climate impacts are equivalent to that of a carbon tax equal to the equilibrium allowance price. When allowances are auctioned, there is also an equilibrium revenue stream that can be used to alleviate the coronavirus recession. The policy impacts on the coronavirus crisis therefore mirror those of the revenue-neutral carbon tax.

Note that the market design of particular cap-and-trade markets ensures that the emissions cap is already indirectly tightened following lower-than-expected allowance demand. For example, the EU ETS has a market stability reserve and will start retiring allowances in 2023 if a recession causes firms to bank large amounts of allowances—reducing the intertemporal cap (Perino, 2018). Other cap-and-trade systems, such as the California ETS and the Regional Greenhouse Gas Initiative in the Northeastern United States, have auction price floors. If binding, allowances are (effectively) canceled and the cap is reduced (Perino et al., 2019). Politically, changing the cap may be difficult ex-post, but a tightening of the rules of the market stability reserve in the EU ETS, and raising the auction price floors in the U.S. trading systems, may be more palatable compromises. **Hence, we categorize tightened emissions caps as good for corona and very good for climate.**

[14] In a meta-study, Dinu et al. (2017) find significantly lower incidence of ischemic heart disease (also called coronary heart disease or coronary artery disease) and cancer for people on a vegetarian rather than an omnivore diet (but not a significant relation for cardiovascular and cerebrovascular diseases). Coronary heart disease seems to be a risk factor for complications from coronavirus infection (Ferrari et al., 2020) and the case fatality rate for cancer patients has in some studies been shown to be significantly higher compared to non-cancer patients (Mehta et al., 2020).

A.12 Paying wages of private employees

The consequences of the pandemic for employment will be severe. Drawing on survey data and historical evidence on how layoffs relate to recalls in the U.S., Barrero et al. (2020) have estimated that 42 percent of recent pandemic-induced layoffs will result in permanent job loss. Policies for maintaining jobs that would not have been lost without the pandemic is thus a good option to lessen the burden for both employers and employees. In particular, reducing layoffs implies avoiding transaction costs associated with rehiring once the economy starts to recover (labor search costs). A typical policy of this kind are government wage payments for employees unable to work due to the coronavirus pandemic. This has been a widespread policy announced in many countries as a response to the pandemic. Examples include Sweden and the U.K. where the governments will cover up to 80% of business employment costs.

With regards to the long-term climate effects from this policy the results are however less clear. To some extent it will depend on whether businesses that require support are mostly located in the upper end of the emission intensity distribution. This seems likely given the seeming negative association between labor intensity and emission intensity of industries (see section 4.1 on industry aid).

Once the economy swings back post-recession, jobs may not return to their old levels in industries with severe layoffs. Labor could increasingly get replaced by capital as a result of forced experimentation, where companies adopt new technology or management practices that replaces some of the previous jobs. This shift in the capital-labor share could potentially have a negative climate impact since capital is typically more fossil fuel intensive. Therefore, government wage payments could have potentially beneficial effects on climate change. We refer to section 3.1.1 on industry aid for further discussion. **We conclude that his policy is very good for addressing the coronavirus crisis and neutral-to-good in terms of climate.**

A.13 Extending sick leave provisions

Extending sick leave provisions can help prevent the spread of the coronavirus, especially as many of the workers who are not guaranteed paid sick leave also work in high-contact occupations (Adams-Prassl et al., 2020). Guaranteeing such workers sick leave provisions can be a very effective policy to limit the virus. However, such provisions impose unexpected financial obligations on the firms, imposing part of the cost of managing the health crisis on firms. Unless the government also covers the cost of any sick leave taken, this could force firms to go into bankruptcy. Thus, policymakers need to consider the potential impact on long-term climate policies of bankruptcies in various firms and sectors, which may for example differ in terms of emission intensity. We discuss such impacts further above, in Section 3.1.1 on industry aid. Unfinanced extended sick leave would also increase firms' labor costs and could induce firms to adopt less labor intensive production methods. These can be expected to typically be more emission intense.

We focus on the long-run effects in our conclusion on this so that, without financial support to firms, **the effect on corona is neutral to bad and the effect on climate change is neutral-to-bad.**

A.14 Introducing or tightening renewable portfolio standards

Renewable electricity portfolio standards, which require electric utilities to procure a set amount or percentage of their electricity sales from renewable sources, are a commonly-used performance standard to reduce carbon emissions. Such standards are revenue-neutral from a government perspective, but the incidence is borne by utilities, ratepayers and fossil-fueled power producers while renewable energy developers and installers benefit. Essentially, these standards redirect investment towards green energy at the expense of traditional power producers. Goulder et al. (2016) show that, in general equilibrium with pre-existing distortionary taxes, such portfolio standards can improve economic efficiency by approximately as much as a revenue-neutral carbon tax. Hence, they do not just reallocate investment but also improve overall efficiency. Furthermore, it is likely that job losses in the conventional power sector are offset by additional employment opportunities in the renewable energy sector.

In terms of climate, the upside of this policy is that it does focus exclusively on the power sector and while it does not incentivize coal-to-gas switching or low-carbon technologies like carbon capture and storage, it still has the potential to significantly reduce emissions from power generation. There are long-run climate benefits through the long-lived nature of such renewable power assets, and technological path dependence. **We categorize the corona effect as neutral and the climate effect as good.**

A.15 Tightening air pollution regulations

There is some preliminary evidence that local air pollutants, such as nitrogen oxides (NO_x) and atmospheric particulate matter with a diameter of less than 2.5 micrometers ($PM_{2.5}$) may increase mortality from coronavirus. Ogen et al. (2020) find, for example, the highest mortality in European regions with high NO_x concentrations. Furthermore, Wu et al. (2020) claim that 1 $\mu g/m^3$ increase in ambient $PM_{2.5}$ concentrations across U.S. counties is correlated with an 8% increase in coronavirus mortality. The range of the concentration is roughly 3-15 $\mu g/m^3$. If causal, this is a large effect.[15] If these preliminary findings hold up, they point in the direction of reducing activities such as vehicular traffic, combustion of coal, and heating oil or wood. The co-benefits would be substantial. These

[15] Wu et al. (2020) do not seem to control for other pollutants, such as NO_x, and it is unclear whether they might be capturing the fact that initial outbreaks have gotten furthest in large, well-connected cities, where $PM_{2.5}$ is also high (although they do control for population density).

benefits will also be long-term if the virus becomes endemic, circulating in the population indefinitely.[16]

In terms of economic recovery this policy is likely neutral.

Typically, local air pollution is controlled by standards and planning decisions. Thus, the pragmatic policy would be to tighten air pollution standards. Of course, such air pollution policies tend to also reduce carbon emissions: they could involve switching from coal generation to gas generation, especially near population centers, and boosting less emission-intensive transport. Such policies may involve long-lived investments (into renewable and gas-fired plants to replace coal) which will be long-lasting. They will also generate new interest groups (cyclists, drivers of electric vehicles) and perhaps reduce the power of coal generators.

Focusing on the long-term effects **we categorize this policy as good for corona and good for climate.**

A.16 Encouraging work from home

Working from home due to the corona crisis has resulted in massive amounts of reductions in commuting worldwide. In a recent survey (April 1-5, 2020) of U.S. working behavior, it was reported that 34.1% of the surveyed population had switched to working from home within the last four weeks (Brynjolfsson et al., 2020). This could be potentially impactful. In the U.S around 80-90% commute by car (in the U.K around two thirds; in Sweden roughly 50%). Hence working at home could have a significant short-run impact on climate through reduced emissions from commuting by car. Whether the effect persists post corona is however not clear. This could be the case if the current crisis has revealed that the previous commuting behavior was indeed suboptimal. Recent empirical evidence suggests that this may often be the case (Bamberg, 2006; Larcom et al. 2017; Yang and Yong, 2017). One reason for this has been that individuals seem to under-experiment in normal times and that network-efficiency may thus improve as a result of a forced experimentation (Larcom et al. 2017). One might also argue that positive feedback mechanisms (bandwagon or network effects) may give rise to a path dependence as result of increased adoption and familiarity with new communication technology, which would also increase the likelihood of a permanent effect on the proportion of the population working from home.

Whether working from home becomes the new normal or not will depend on the experiences had by both workers and employers. Government policies could however help incentivize continued work from home post corona. Examples of such policies are:

[16] Parry et al. (2014) estimate the co-benefits associated with a reduction of local air pollutants would already be substantial just for a reduction of coal burning—the co-benefits alone would justify a U.S. carbon price of $\$35/tCO_2$, of which 30% is due to NO_x and $PM_{2.5}$ emissions. Higher coronavirus mortality rates would increase such co-benefits.

- Subsidizing work from home equipment (e.g., adjustable desks, chairs, computers).
- Removing possibilities for companies to deduct business travel costs.
- Legislation on 'right to work from home'.
- Investing in IT infrastructure / improving connectivity when working remotely.

A key IT infrastructure investment is 5G. 5G will enable remote controlling machines and robots from a distance which could have an impact in many areas ranging from mines to medical surgery (Lema et al., 2017). The 5G technology saves energy by streamlining the control of radio signals and by transferring only what is really needed – no superfluous system information needs to be handled. In smart cities, public transport and other means of transportation can be adapted to external circumstances and to people's intentions. The same applies to water consumption, waste management and other community services.

The effect on corona is an immediate reduction in virus spread, health care costs and reduced sick leave. In the long-term, employers' gains come from a more productive workforce which uses less space and is more cost effective to house, and workers gain from the prospect of a better work-life balance, thereby increasing levels of job satisfaction and organizational commitment (Felstead and Henseke, 2017). However, when it comes to labor, apart from jobs created from IT infrastructure investments, it is unclear whether any net positive effect on jobs may result from any other 'work from home' targeting policies. It may however have substantial relocation effects in terms of migration from city to countryside.

Based on the above discussion **we categorize the climate effect as good and the corona effects as neutral in the long-run**.

A.17 Promoting active modes of transportation

Passenger cars account for about 13% of European CO_2 emissions. Empirical research shows that commuting distance, low fuel prices, lack of attractive alternatives, and free workplace parking favors using the car over alternative modes of transportation (Buehler, 2011; Carse et al., 2013; Gillingham and Munk-Nielsen, 2019). City planning policies and infrastructure investments could alter that conclusion by making car travel more expensive (e.g., congestion charging), less convenient, and subsidizing public transportation (Winters et al., 2011). Neves and Brand (2019) find that about 41% of short car trips could in theory be replaced by cycling or walking, reducing emissions from car travel by about 5%. We already see initiatives along these lines. Milan plans to reallocate 35 kilometers of street space from cars to cycling and walking in the summer of 2020, in response to the coronavirus crisis. Given path dependencies of infrastructure investment and forced experimentation, initiatives like this can also foster persistent change.

The channels involved are through investment and learning, but a shift towards active modes of transportation could also have long-run health effects. For one, there are some indications that

coronavirus is more severe in regions with poor air quality. Comparative studies show that cities, regions and countries with a higher proportion of people commuting using active modes of transportation see lower rates of obesity, diabetes, and hypertension (Pucher et al., 2010; Rasmussen et al., 2016; Grøntved et al., 2016). This reduces the share of people vulnerable to the coronavirus. **We categorize the corona effect as good and the climate effect as good.**

A.18 Conditions on bailouts

Some countries (France, Denmark, and Poland) are conditioning public support of corporations on tax residency, effectively ruling out supporting firms which are based in low-tax jurisdictions (Mallet, 2020). There has also been a broad debate about bailouts to firms in polluting sectors (Carrington, 2020). However, several airlines, for example, have already been given bailout loans with no conditions attached (Laville, 2020). The bailout given to Air France contains the requirement that Air France halve its carbon emissions accruing from domestic routes, essentially forcing it to cut back services on routes (Financial Times, 2020). Some countries, such as Canada, have conditioned support on future environmental performance (France24, 2020).

How well can government-provided financial support be conditioned on environmentally responsible behavior? To the extent such conditioning focuses on future behavior, any promises extracted may suffer from time-inconsistency issues, and from difficulties in writing sufficiently complete contracts. However, if a bailout can be credibly conditioned on future changes in activity, and if, in the absence of bailouts, the industry is likely to resurrect after any bankruptcies, then conditional bailouts of emission-intensive sectors may be beneficial to the climate. Consider airlines: a wave of bankruptcies will wipe out current shareholders, but the aircraft assets will be sold to new companies once the health crisis subsides, and these new firms will operate according to market forces. A bailout will save the current firms, but it can set conditions on their future behavior, such as reducing the number of short-haul flights for which feasible low-emission alternatives exist.

Recapitalization is an alternative to conditional bailouts. Rescuing firms by injections of equity using public funds are, effectively, partial nationalizations. As such, they give the state an ownership stake in the firm, and thus a voice in the management of the firm. Many commentators warn against the state taking a role in commercial decisions, even in situations in which it does hold a stake. However, where a firm's commercial decisions involve important externalities, it may be justifiable to have the state exercise its owner's right to influence commercial decisions so as to take account of social costs of these decisions. The recapitalization should be large enough to give a state an important voice as a major shareholder. The channels involved here are thus through long-lived investment and political status quo. **We categorize the corona effect as neutral-to-good and the climate effect as neutral to good.**