Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
Slouching or speeding toward net zero? Evidence from COVID-19 energy-related stimulus policies in the G20

Kevin Andrew a, Basma Majerbi a,⁎, Ekaterina Rhodes b

a Gustavson School of Business, University of Victoria, Canada
b School of Public Administration, University of Victoria, Canada

ABSTRACT

This paper analyzes the size and nature of green fiscal stimulus in the G20 countries in response to the COVID-19 crisis, with a focus on the energy-related policies. We exploit a new dataset, the Energy Policy Tracker (EPT), with detailed information on countries’ policies since the start of the pandemic. Between January 2020 and December 2021, G20 countries enacted 913 stimulus measures that have direct impacts on energy supply and demand. The average country spent $395 USD per person on energy-related policies. Only 30% of this amount, on average, is devoted to low-carbon measures, mostly in the transit and buildings sectors, with considerable variation across countries. To properly compare countries’ efforts in aligning their COVID-19 stimulus with climate goals, we construct a new index, the Green Energy Policy Index (GEPI), using principal components analysis, taking into account both “green” and “brown” stimulus measures. The GEPI varies considerably across countries. We find that on average, countries with a “greener” energy-related stimulus are wealthier and have a lower emission intensity. On average, countries that have experienced the crisis more acutely, both in terms of deaths and gross domestic product (GDP) loss, have “greener” stimulus packages. We discuss the implications of these findings for future research and climate energy policy-making.

1. Introduction

The COVID-19 pandemic has had significant negative effects on economic activity globally. For example, the gross domestic product (GDP) for the G20 contracted by 8.9% during the second quarter of 2020 (OECD, 2020). In response to the crisis, most countries adopted massive fiscal and monetary stimulus measures to help households and businesses navigate the downturn. Globally, additional fiscal spending and forgone revenues approached $20 trillion as of March 2021. This amount includes liquidity support from central banks, government guarantees, and quasi-fiscal operations, according to the International Monetary Fund (IMF) Fiscal Monitor Database as of April 2021. Additionally, the pandemic brought greater awareness of the systemic risks and their potential damaging effects, with climate change and rising inequalities moving to the top of the agenda (World Economic Forum, 2021). This led to growing calls to “build back better” and prioritize a green and sustainable recovery. As the scale of the required policy response became clear, calls for green fiscal stimulus, including measures to address both economic and environmental goals, intensified (NGFS, 2020; Dikau et al., 2020; Hepburn et al., 2020; Caldecott, 2020).

A green fiscal stimulus measure has the dual objective of stimulating economic activity in the short term while also preserving the environment (Strand and Toman, 2010). Arguments in favor of green stimulus focus on the potential co-benefits to both the economy and the environment. Barbier (2010) argued for a “Global Green New Deal” to help transition the global economy away from fossil fuels while stimulating growth. Others point to the systemic risks to the financial sector posed by climate change (NGFS, 2020). Concerns over climate change predate the current economic crisis, with a scientific consensus regarding the necessity of achieving net-zero emissions by 2050 (IPCC, 2018; IPCC, 2021; IEA, 2021) leading 197 countries to endorse the Paris Agreement. Considering the scale of investments required to decarbonize the economy and meet global emissions reduction goals, and given the increased urgency to tackle the climate crisis, it makes sense for governments to align their fiscal stimulus in response to the COVID-19 pandemic with their long-term climate goals.

⁎ Corresponding author at: PO Box 1700 STN CSC, Victoria, BC V8W 2Y2, Canada.
E-mail address: majerbi@uvic.ca (B. Majerbi).

This refers to the year-over-year percentage change for the entire G20. Therefore, the real GDP in the G20 was 8.9% lower in the second quarter of 2020 than in the second quarter of 2019.
Despite the compelling case and increased pressure on governments to prioritize climate goals when designing their stimulus packages (Hepburn et al., 2020), the macroeconomic and environmental effects of such policies post-implementation are not fully understood (Agrawala et al., 2020). Given that public funds and support for climate mitigation and adaptation are scarce during times of economic crisis, it is important that policy-makers have a better understanding of the efficacy of green fiscal stimulus.

In this paper, we contribute to the debate regarding the efficacy of green fiscal stimulus by laying the groundwork for future research to answer this question in the context of the COVID-19 crisis, since it is currently too early to conduct an ex-post evaluation analysis. Our study has the following three objectives: (1) analyze the extent of green fiscal stimulus in response to the COVID-19 pandemic in the G20 countries; (2) develop an aggregate measure that captures the “greenness” of fiscal stimulus; and (3) explore the relationship between this green recovery index and country characteristics. For the latter, we include indicators of the level of economic development, emission intensity, size of the overall policy response, and the severity of the pandemic.

We exploit a new dataset, the Energy Policy Tracker (EPT, 2021), which contains detailed information on publicly announced direct fiscal policy interventions that affect the production and consumption of energy since the start of the pandemic.5 As of December 14, 2021, the EPT included 913 measures for the G20, which include 19 countries and the European Union (EU). One advantage of using the EPT dataset is that the definition of energy policies is broad and covers measures related to transportation, utilities, oil and gas extraction, manufacturing, landfill waste, and buildings. These sectors account for about 80% of global emissions. The G20 country sample in our analysis, accounting for approximately two-thirds of world emissions, provides a good overview of the extent of green stimulus in the global economy in response to the COVID-19 pandemic.6 Thus, our study addresses a major gap in the literature by enabling cross-country comparisons of green fiscal stimulus at a time of crisis. As explained in the next section, there are limited single-country studies that investigate individual components of green fiscal stimulus.4

Next, we propose a new measure that can be used to rank countries in terms of the greenness of their energy-related fiscal stimulus. We call this the Green Energy Policy Index (GEPI). When constructing the index, we take into consideration the size of stimulus spending that is devoted to low-carbon measures and the amount that is devoted to supporting fossil fuel-intensive sectors. Additionally, we account for the size of the overall stimulus package within a given country. The index is constructed using principal components analysis (PCA) and offers an easy-to-interpret and more holistic way to compare countries by including both “green” and “brown” fiscal stimulus measures. We provide more details on the construction of the index and its advantages in the methods section.

The rest of the paper is organized as follows: Section 2 provides brief theoretical and empirical background on the concept of a “green” fiscal stimulus in the context of macroeconomic stabilization policies. Section 3 introduces the data and methods. Section 4 presents our main results. Section 5 discusses the limitations of this study and ways to address them, and the final section concludes the paper and offers avenues for future research.

2. Theoretical and empirical background

Green fiscal stimulus is related to the extensive literature on the efficacy of fiscal policy. Fiscal policy can include tax cuts, transfers to businesses and households, and government spending. The Global Financial Crisis (GFC) of 2008–2009 renewed interest in quantifying the effectiveness of fiscal stimulus to speed up economic recovery after a downturn. The traditional approach by economists to this question focuses on the magnitudes of the fiscal multipliers. The concept of a multiplier is central to traditional Keynesian economic policy and measures the effects of a given change in taxation or spending (Keynes, 1936). The government-spending multiplier is the number of dollars that increase in aggregate GDP for each dollar of government spending. For example, if the marginal benefit of one dollar of government spending is greater than one dollar in the short term, then government spending has the potential to stimulate economic activity. There is substantial recent empirical work on fiscal multipliers (Ramey, 2019; Chodorow-Reich, 2019) with a consensus that government-spending multipliers range between 0.5 and 2. Notably, this work finds that both the state of the economy and the type of stimulus are important determinants of the multiplier. Furthermore, if government spending leads to future fiscal consolidations, it could put the economy on a slower recovery path in the medium- to long-term (Fatás and Summers, 2018). Evidence suggests that the magnitude of the tax multiplier is higher and that the range widens once we consider different types of fiscal stimulus, such as infrastructure spending versus military spending.

However, standard estimates of fiscal multipliers may not be appropriate for evaluating the efficacy of green fiscal stimulus. Given that these policies have a dual aim of stimulating the economy while reducing emissions, a multiplier of less than one can be justified by large reductions in emissions. Moreover, standard multipliers measured by GDP growth do not account for environmental degradation (e.g., flooding or forest fires due to climate change); in this case, the GDP would grow because environmental degradation creates new jobs and new economic activity (Costanza et al., 2014). Therefore, comparing the effectiveness of various fiscal policies based on multipliers may not capture the full benefits or damages related to a given policy or government spending.

Discussing the merits of green fiscal stimulus has gained more attention in the wake of the GFC. Large fiscal stimulus packages worth more than 3 trillion USD were mobilized in response to the GFC, of which 16% was devoted to lowering greenhouse gas emissions. Most of this spending took place in G20 nations. This green stimulus included support for renewable energy; carbon capture and sequestration; energy efficiency; public transport; and improving electrical grids (Barbier, 2010; Robins et al., 2009).

With the advent of the COVID-19 crisis and the massive mobilization of government stimulus packages that far exceed those implemented during the GFC, more calls for green fiscal stimulus emerged. However, ex-post analyses on the efficacy of green fiscal stimulus are still relatively scarce, especially in terms of cross-country comparisons (Agrawala et al., 2020). Some empirical work has focused on single country cases, such as the United States (U.S.) American Recovery and Reinvestment Act, which had several green provisions (Mundaca and Richter, 2015). Additional studies used data on local labor markets to identify the effects of green stimulus on employment. Popp et al. (2020) found that each million dollars of green recovery spending in the
American Recovery and Reinvestment Act created 15 new jobs in the long term with little evidence of short-term employment gains. Vona et al. (2019) found that green employment grew quicker than non-green employment after the GFC. They attribute this to green stimulus policies and argue that because green jobs are highly skilled and well paid, they carry a high job multiplier. Their preferred estimate is that one green job leads to 4.2 additional jobs. Furthermore, recent evidence from a panel of countries estimates that the output multiplier on green renewable energy investment is 1.5. This is three times higher than the multiplier on traditional energy investments (Batini et al., 2021).

Further research is needed to identify the impact of green fiscal stimulus on emissions and evaluate evidence outside of the U.S. context. For instance, evidence from South Korea suggests that the Korean Green New Deal did not lower the emissions trajectory (Sonnenschein and Mundaca, 2016).

Theoretically, the potential benefits from green fiscal stimulus are unclear in terms of emissions reduction. There is some justification for arguing that economic downturns are not the appropriate time to address environmental concerns because emissions tend to decrease during recessions. Work using environmental dynamic stochastic general equilibrium (DSGE) models finds that the optimal carbon price should fall during economic downturns (Heutel, 2012; Golosov et al., 2014). In addition, recent survey evidence from Germany suggests that individuals are less likely to support climate-oriented stimulus during difficult economic times (Engler et al., 2021). However, many leading climate jurisdictions have used crises as a policy window to implement new climate policies. For instance, the province of British Columbia in Canada enacted an economy-wide carbon tax, low-carbon fuel standard, and a clean electricity standard in the wake of the GFC, while the public’s focus was on economic recovery and there was a lack of attention to environmental issues (Harrison, 2010).

Irrespective of the economic multipliers, green fiscal stimulus has the potential to reduce greenhouse gas emissions, which will mitigate future climate change. Measuring the effectiveness of green fiscal stimulus may require the use of other tools and indicators alongside fiscal multipliers. For instance, the social cost of carbon is an effort to quantify the overall damages of an additional metric ton of carbon dioxide emissions. This concept includes non-economic costs, such as mortality and loss of biodiversity. Estimates of the social cost of carbon vary, ranging from 40 USD to 300 USD per ton (Nordhaus, 2017; Pindyck, 2019). Considering the benefits of reduced emissions and avoiding this high social cost of carbon means that green fiscal stimulus can be desirable, even with moderate economic multipliers. The relative weighting of the stimulus versus environmental aspects in policy-making is a normative issue.

These are important questions for future research with valuable policy implications. The COVID-19 crisis offers a natural experiment to study the effectiveness of green fiscal stimulus in both improving economic conditions and reducing emissions. While it is too early to measure such impacts, our paper contributes to this effort by documenting the greenness of recent stimulus packages and proposing an indicator that will be easy to use in future ex-post evaluation studies.

3. Materials and methods

3.1. Taxonomy of green fiscal stimulus

To classify a policy as green fiscal stimulus, we adapt Strand and Toman’s (2010) definition of green stimulus as measures that are aimed at stimulating short-term economic activity while reducing greenhouse gas emissions. These reductions may occur in the short term or materialize over a longer period. Note that we define green stimulus based on the policy-makers’ stated intent. For example, if a government announces an investment in energy efficiency with the intention of creating jobs and reducing emissions, this is considered as green stimulus.

This definition is broad enough to include a variety of fiscal policy measures, including cash transfers, new taxes, tax deferrals and subsidies, and other interventions by national, subnational or other arms of government as explained below. Moreover, previous literature has emphasized several dimensions of fiscal policies when creating classification schemes. Khatiwada (2009) classifies fiscal stimulus into spending on public goods, stimulus aimed at consumers, and stimulus aimed at firms.

The classification of environmental policies was addressed by Goulder and Parry (2008). Among fiscal policies, they evaluate emission taxes, tradable emission allowances, and subsidies for emission reductions and research. Flexible regulations that incorporate elements of carbon pricing are also included as fiscal policy instruments (Rhodes et al., 2021). Hepburn et al. (2020) developed 25 fiscal policy archetypes and surveyed 231 policy-makers and experts on their environmental and economic benefits.

For the purpose of our paper, and given our focus on energy-related policies, we follow the EPT methodology and adapt it to classify fiscal stimulus policies into the following three main categories based on their environmental profiles and potential impact on future emissions: low-carbon, fossil fuel-conditional (fossil-conditional), and fossil fuel-unconditional (fossil-unconditional) measures. A fourth category (unclassified) includes measures with unclear implications. We provide more details on policy category coding in the Supplementary Material document available online.

**Low-carbon** stimulus measures support the production or consumption of energy with the aim of reducing the environmental impact. The key characteristic of this category is that these measures include direct government spending, flexible regulations, or tax changes that are aimed at reducing emissions through either fuel switching or efficiency. Examples include support for energy efficiency, renewable energy, and active transport. Moreover, we include in this category measures that could support the transition away from fossil fuels with appropriate conditionality, such as measures that support electric vehicles, smart grids, public transit, biomass, and hydrogen. The ways in which these measures are implemented vary. Common mechanisms include subsidies to business and consumers, carbon taxation, and government investment. Subsidies may include incentives for households to purchase electric vehicles or subsidies for businesses who engage in research and development with the aim of reducing their carbon footprint. Government investments include several measures, such as building electric vehicle charging infrastructure and renewable energy capacity.

**Fossil-conditional** stimulus measures include support for the consumption or production of fossil fuels, such as oil, gas, and coal, with explicit conditions targeting reducing emissions. The key characteristics of these measures are that they attempt to mitigate the damage of fossil fuels rather than reduce dependence on them. Such conditions include emissions, or emission intensity reduction targets, and requirements to reduce environmental damages due to methane leakage. An example of a policy in this category is the French governments’ bailout of the aviation sector. This bailout is conditional on reducing future emission intensity. The mechanisms used by governments in this category include government investments, taxes, subsidies, and loans.

**Fossil-unconditional** stimulus measures support fossil fuel reliant industries without any conditions for reducing emissions. Examples of policies in this category include the bailout of the aviation sector in the U.S.; subsidies and regulatory rollbacks in the oil and gas sector; and bailouts for the auto sector in most countries.

**Unclassified** stimulus measures include all remaining policies that do not fit into one of the defined categories. These include measures that could have both green and non-green implications, such as support for nuclear energy.

Table 1 presents examples of policies from the EPT dataset and how the have been classified across the three main categories in our study, showing both spending and non-spending policy examples.
measures for the 19 G20 countries and the EU were documented in the
sub-national policies. There are 590 national policies are included in our analysis. Sub-national policies
direct spending, we use the dollar figure in USD. Both sub-national and
financial commitments of these governments. In the case of regulatory
changes, there are no financial commitments. For policies involving
direct spending, we use the dollar figure in USD. Both sub-national and
national policies are included in our analysis. Sub-national policies include province, state, and territory interventions. There are 590 measures at the national level, and the remaining 323 are at the sub-national level. In all figures presented in the remaining of the paper, spending by sub-national units is included as part of the corresponding country total.6

The main data source for this paper is the Energy Policy Tracker (EPT, 2021) as mentioned above. The dataset is maintained by a coalition of public policy think tanks and academic institutions. It is constructed using a bottom-up data construction methodology and has been subject to internal peer review. This database contains detailed information on the universe of publicly announced direct policy interventions that have an impact on the production and consumption of energy introduced as part of stimulus packages in response to the pandemic with a starting date set as of January 1st 2020. As of December 14, 2021, a total of 913 measures for the 19 G20 countries and the EU were documented in the EPT. The tracker includes policies that affect both the regulatory and financial commitments of these governments. In the case of regulatory changes, there are no financial commitments. For policies involving direct spending, we use the dollar figure in USD. Both sub-national and national policies are included in our analysis. Sub-national policies include province, state, and territory interventions. There are 590 measures at the national level, and the remaining 323 are at the sub-national level. In all figures presented in the remaining of the paper, spending by sub-national units is included as part of the corresponding country total.6

The mechanisms through which the policies in the EPT work are various, and the most common mechanism is government investments which account for 58% of the policies. Loans and loan guarantees to private companies comprise 5.3% of the policies, including most aviation and auto sector bailouts, and new and extended regulations comprise 14.5% of the policies. These include the phasing out of coal in Germany and the Clean Fuel Standard in Canada. Lastly, 4.3% of policies are for regulatory rollbacks or fee breaks. These include the delay or elimination of environmental penalties and the removal of regulations regarding drilling for fossil fuels. The remaining 18% of policies are not easily classified due to the lack of description.

We construct several variables to characterize a country’s green stimulus response based on the categorization outlined in the previous section. For each country, we calculate the share of spending allocated to low-carbon, fossil-conditional, and fossil-unconditional measures, including all announced spending during the period covered by this study. It is important to note that some of this spending will occur over several years. In the EPT dataset, policies are classified as clean conditional or clean unconditional if they support the production or consumption of energy that is low carbon. The difference between clean-conditional and clean-unconditional stimulus measures is due to the extent of provisions that limit environmental degradation. We group these two categories together to construct our share of low-carbon stimulus. Additionally, we calculate the total amount of energy spending per capita. The EPT database classifies policies into the following four broad sectors: mobility, buildings, resources, and power generation. The resource sector includes measures that impact the extraction of fossil fuels, and the power generation sector is related to the generation of electricity.

In our analysis, we further categorize policies within the mobility sector into transit, automotive, aviation, and infrastructure. We do this based on a line-by-line reading of the documentation available for each policy in the dataset. We also distinguish between renewable and fossil fuel policies in the power generation sector.

3.3 Methods

3.3.1 Constructing the GEPI

To quantify the “greenness” of the energy-related COVID-19 stimulus

| Policy Type            | Classification       | Examples                                                                 | Country     | Sector            | Amount (Billion USD) |
|------------------------|----------------------|-------------------------------------------------------------------------|-------------|-------------------|----------------------|
| Non-Spending Measures  | Low Carbon           | Memorandum of Understanding signed to set up 5000 compressed bio-gas plants | India       | Multiple/Other (Biofuels) |                      |
|                        | Fossil Conditional   | Introduction of a new vehicles tax based on their CO2 emissions          | Germany     | Auto              |                      |
|                        | Fossil Unconditional | Reactivation of Rio Turbio coal plant                                    | Argentina   | Power             |                      |
| Spending Measures      | Low Carbon           | Residential retrofit and energy efficiency program investment           | Canada      | Generation Buildings | $1.9                 |
|                        | Fossil Conditional   | Government backed loans to Air France airline company with climate strings attached | France | Aviation | $7.7                |
|                        | Fossil Unconditional | Department of Treasury to use Coronavirus Aid, Relief, and Economic Security (CARES) Act to provide financial support to airline companies | USA | Aviation | $58.0               |

Source: Energy Policy Tracker’s (2021) and authors’ classification.

---

6 In an initial version of this paper, we analyzed 578 measures for G20 countries available in the EPT dataset as of December 31, 2020, including 381 national and 197 subnational measures. We include various analysis of the GEPI index constructed based on this reduced set of policies in the Supplementary Materials. The ranking of the countries based on the reduced set was slightly different (Table C.4 vs. Table 4 in this paper). Figure A.5 plots the index used in this version of the paper against the index constructed using 2020 data. In an initial version of this paper, we analyzed 578 measures for G20 countries available in the EPT dataset as of December 31, 2020, including 381 national and 197 subnational measures. We include various analysis of the GEPI index constructed based on this reduced set of policies in the Supplementary Materials. The ranking of the countries based on the reduced set was slightly different (Table C.4 vs. Table 4 in this paper). Figure A.5 plots the index used in this version of the paper against the index constructed using 2020 data.
In a previous version of the paper, we included the share of all policies (spending and non-spending combined) in our index construction. This choice meant that countries that spread the same amount of spending out over more announcements would have a higher policy share variable entering the index. We thank an anonymous referee for pointing this out. Section B of the Supplementary Materials replicates our results using the previous methodology. Figure A.4 shows that the change has no substantive effect on the index. The correlation between the index constructed using our previous methodology and the new index using the share of non-spending policies is 0.99. The Spearman rank correlation is 0.975.

We use real GDP per capita and real GDP growth from the World Bank Open Data Archive to investigate whether developed or emerging economies are more or less likely to adopt green fiscal stimulus. Additionally, we include Elgin et al.'s (2020) policy index in our correlation analysis. This allows us to check whether countries that have a higher overall policy response have a greener energy-related response, or vice versa. We also include average real GDP per capita growth over the pre-pandemic period, 2010–2019. High-growth emerging economies, such as India and China, will have to play a key role in the transition to a net-zero global economy. We are therefore interested in investigating potential relationship between growth in living standards and the GEPI.

As mentioned before, one important topic of discussion in the aftermath of the COVID-19 crisis is whether economies will “build back better” (Zachariadis et al., 2021). Countries with high emission intensities could use the crisis as an opportunity to pivot into a low-carbon economy by strategically focusing their stimulus efforts on sectors that play a key role in the net-zero transition. To explore this hypothesis, we collect greenhouse gas emissions data, measured in tons of CO2e, from the World Bank and calculate the emission intensity ratios for G20.11 Emission intensity is measured in megatons of CO2 emissions per billion USD of output. Additionally, we include the share of renewable energy in consumption from the World Bank to explore whether the countries' existing energy mix affects how they direct their stimulus packages since these measures and policies impact energy supply and demand.

Our last set of variables reflects the severity of the COVID-19 crisis that triggered these economic stimulus packages. We include both economic- and health-related variables. We are interested in the relationship between green stimulus and the severity of the crisis because countries that have a more acute health crisis may be less focused on other policy objectives, such as climate change mitigation. The COVID-19 mortality rate comes from Worldometers (2020) and measures the total number of COVID-19-related deaths per 100,000 population. We calculate the GDP decline, which is measured in percentage terms, from the maximum percentage year-over-year decline in quarterly GDP over the first three quarters of 2020 at the onset of the pandemic. Quarterly data comes from the OECD (2020). For most countries, the maximum decline occurred in the second quarter; however, for China, it occurred in the first quarter.

We also include the share of the population over the age of 65 from the World Bank. This captures the vulnerability of a given economy to COVID-19. It is well established that mortality risk from COVID-19 rises with age (Worldometers, 2020). Therefore, countries with a higher elderly share of the population are more exposed to this risk. In the Supplementary Material, we also include hospital beds per 1,000 of population and air pollution as additional variables of interest in the correlation analysis.

4. Results

4.1. Country level summary

We first synthesize the shares of green spending and policies. Out of the 913 measures for G20 countries covered in the EPT, as of December 2021, 47% are classified as low carbon, 8% are fossil conditional, and 30% are fossil unconditional. The remaining measures are unclassified.11
Approximately 70% of the policies are classified as fiscal, while 4.8% are classified as monetary. All monetary policy measures are conducted through the COVID-19 Corporate Financing Facility via the Bank of England and take the form of liquidity support for struggling companies. Our analysis includes these measures, as similar policies are classified as fiscal in other countries. The remainder of the policies cannot easily be classified as fiscal or monetary.  

Table 2 presents summary statistics of all the data used in the paper. The upper panel summarizes the key variables used to construct the GEPI. On average, the share of spending on low-carbon stimulus measures across the G20 represents 30% of the total spending measures announced between January 2020 and December 2021, with large variation across countries ranging from 0% to 92%. On average, non-spending low carbon measures account for 36% of the total number of policies. Non-spending fossil unconditional policies average 36% across the G20 while fossil unconditional spending averages 53%. The average G20 country spent $395 USD per capita on measures that directly impact energy supply and demand. Overall, we document a considerable variation regarding the greenness and size of energy-related stimulus policies.

The lower panel of Table 2 presents summary statistics for the variables used in the correlation analysis. First, the average CO2 intensity is 0.44 megatons per billion USD of output. The share of renewables used in energy consumption is 14% on average. The variation in both these measures is substantial. The demographics of G20 countries vary substantially, with an average share of the population over the age of 65.

### Table 2

| Statistic                         | N   | Mean | St. Dev. | Min | Max |
|----------------------------------|-----|------|----------|-----|-----|
| Low Carbon USD (%)               | 20  | 0.30 | 0.28     | 0.00| 0.92|
| Fossil Cond. USD (%)             | 20  | 0.03 | 0.06     | 0   | 0.22|
| Fossil USD (%)                   | 20  | 0.53 | 0.38     | 0.00| 1.00|
| Low Carbon Pol. (%)              | 20  | 0.36 | 0.28     | 0   | 1.00|
| Fossil Cond. Pol. (%)            | 20  | 0.13 | 0.23     | 0   | 1.00|
| Fossil Pol. (%)                  | 20  | 0.36 | 0.27     | 0   | 1.00|
| EPT Spending/Person (USD)        | 20  | $395 | $584     | $11 | $2223|
| CO2 Intensity                    | 20  | 0.44 | 0.30     | 0.11| 1.07|
| Renewable Share (%)              | 20  | 14.38| 10.54    | 0.02| 47.06|
| Pop 65+ (%)                      | 20  | 13.78| 6.74     | 3.31| 27.58|
| GDP/Capita (USD)                 | 20  | $27,057| $19,375| $1997| $63,064|
| GDP Growth (%)                   | 20  | 2.87 | 1.99     | 0.27| 7.68|
| GDP Decline (%)                  | 20  | 12.37| 6.21     | 2.80| 23.50|
| COVID Mortality Rate             | 19  | 50.93| 44.26    | 0.32| 124.11|

The top panel summarizes the statistics for the variables underlying the construction of the GEPI. The numbers in this panel represent the fraction of each type of policy in total spending (in USD) and in the total number of non-spending policies (referred to as Pol.). All data on these policies is from the Energy Policy Tracker (2021). N refers to the number of countries. The bottom panel summarizes the statistics for other variables that were used in our correlation analysis. CO2 intensity is measured in megatons of CO2 equivalent emissions per billion USD of GDP (as of 2018), where greenhouse gas emissions are taken from the World Bank database. The GDP and demographic variables are taken from the World Bank Open Data Archive. The COVID-19 mortality rate is calculated based on data from Worldometers (2020) using the total number of COVID-19-related deaths per 100,000 population. The GDP decline variable measures the largest quarter-over-quarter percentage decline during the first three quarters of 2020. The quarterly GDP data is from the OECD (2020).

12 The distinction between monetary, fiscal and other is not included in the most recent version of the EPT data so the figures relate to the December 2020 dataset. At that time 12 of 15 monetary policies were through the UK COVID-Corporate Financing Facility. This policy was designed to provide liquidity support to large firms. Similar policies were implemented in other countries through the fiscal authorities. For example, the CARES act included $500 billion in loans for corporations.
vehicles when accompanied by some conditionality to lower emissions, and bailouts for auto companies with green conditionality. These bailouts target R&D to improve fuel efficiency or develop electric vehicle technologies. In the power generation sector, fossil-conditional investments support the transition toward natural gas.

The right panel of Fig. 2 shows the absolute number of non-spending policies implemented by sector. The size of the financial commitments does not always align with the number of policies because regulations and other policies without announced costs are used as part of energy policy stimulus packages. This is particularly true in the resource sector, where 50% of measures are changes to regulations, the majority of which translate into unconditional support for fossil fuels. On the other hand, the power generation sector has a high number of regulatory changes at 26%. Of these, only 22% are fossil unconditional. The resource extraction and utilities sectors are heavily regulated, which means that changes in government regulations could have substantial effects on future emission pathways. The extent to which regulatory changes reinforce public investments in green infrastructure is an important consideration. There is a concern that even within countries, large-scale efforts to reduce emissions through public investment could be thwarted by regulatory changes. Barbier (2020) argues that the lack of sufficient carbon pricing and regulatory changes is a major reason for the ineffectiveness of the green stimulus in the wake of the global financial crisis.

4.2. The GEPI

In order to properly rank countries based on how green their overall response to the COVID-19 crisis has been, we construct the GEPI based on both “green” and “brown” policies and accounting for both spending and non-spending measures as described above. Table 3 presents the statistics from the PCA procedure to create the index. The top panel provides information regarding the amount of variation in the underlying data that each principal component accounts for. The first principal component accounts for the most variance. In our case, the first component, which represents the loadings used in our index, accounts for 42% of the variation in the underlying data, whereas the second component accounts for only 20% of the variation.14

The bottom panel of Table 3 shows the factor loadings on each of the principal components (PC1 to PC7). Positive factor loadings imply that a variable is added to the index positively, while negative loadings imply that a variable negatively affects the index value. The magnitudes represent their respective weights. Note that variables are standardized before aggregating. The GEPI is constructed using PC1. The factor

---

13 We acknowledge that not all new vehicle purchase incentives qualify as fossil conditional and reviewed the detailed policy documents to assess the attached conditionality. Table A.5 in Supplementary Materials includes a detailed analysis of all automotive purchase incentives in our dataset. Such measures are classified as fossil conditional if there is sufficient conditionality for lower emissions intensity or for switching to EVs. If there is no conditionality then the measure is classified as fossil unconditional. There are only seven such policies during the sample period. Further details are provided in the caption of Table A.5.

14 For context, in the literature on socio-economic status indices, such as in Vyas and Kumaranayake (2006), the first principal component accounted for between 12% and 27% of the variation in the data. The first principal component in Beijn et al. (2020) accounted for 27% of the variation in the data.
loadings are positive for low-carbon and fossil-conditional spending and non-spending policy shares, and the overall EPT spending per capita. The factor loadings are negative for fossil-unconditional spending and non-spending policy shares. Furthermore, the magnitudes of the factor loadings range from 0.19 to 0.47 in absolute values, which represents a relatively tight range. Based on these numbers and signs of the factor loading, the GEPI is easy to interpret. A higher value means a relatively higher focus on green stimulus policies.

Table 4 lists the G20 countries in descending order of the GEPI. The top-ranked country is France with a GEPI of 2.96. This high number is driven by a relatively low share of policies and spending on unconditional fossil fuels compared to the shares of low-carbon- and fossil-conditional policies. The following three countries—Canada, Germany, and Italy—are all advanced economies with over half of their spending devoted to low-carbon and fossil-conditional investments. These top four countries, as well as the UK, have the largest overall spending per capita (over $840 USD) based on policies tracked by the EPT as of December 2021. As these pandemic recovery policies affect energy supply and demand, it would be interesting to assess their effectiveness in contributing to accelerating these countries’ low carbon transition. We leave this for future research to investigate how emission trajectories may have shifted post-pandemic. Our GEPI can be easily extended to include more countries and stimulus policies beyond December 2021, as countries continue to implement other recovery measures to deal with subsequent waves of the pandemic.

The lowest ranked countries in Table 4 have nearly 100% of their EPT-tracked spending dedicated to fossil-unconditional measures. For example, Turkey’s total spending of $168 USD per capita only comprises measures that fall 99% under the fossil-unconditional category. Furthermore, for these countries, a substantial fraction of the non-spending measures fall under the fossil-unconditional category (e.g., this number reaches 100% and 60% for Argentina and Russia, respectively). The two exceptions are Indonesia and South Africa, where approximately one third of their non-spending policies are aligned with moving to a low-carbon future. Additionally, Russia and Argentina have dedicated almost all their stimulus spending to fossil-unconditional measures.

The U.S. and South Korea, ranked 15th and 10th, respectively, are interesting countries to analyze because both countries had large green stimulus programs in the wake of the GFC. Korea’s spending of $123 USD per capita is below the G20 average in the EPT dataset. This is not surprising given that Korea is one of the least affected countries by the COVID-19 shock in the G20, both in terms of GDP decline and COVID-19-related deaths. Only 21% of its 2020–2021 stimulus spending went to low-carbon measures, with the balance representing fossil-unconditional measures. Note that some studies that investigated Korea in the wake of the GFC suggest that although the Korean Green New Deal did not successfully reduce emissions, it was effective as economic stimulus (Sonnenchein and Mundaca, 2016). As of December 2021, the U.S. has a large spending presence in the EPT at $301 USD per capita, of which 73% is aimed at fossil-unconditional support. Most spending is targeted at the aviation industry. Moreover, 77% of the non-spending measures in the US are classified as fossil unconditional, resulting in such low ranking among its G7 peers.

One benefit of using a data reduction method, such as PCA, is that we document in a single variable multiple facets of the greenness of fiscal stimulus. As shown in Table 4, our GEPI index displays considerable variation across countries. It is too early to investigate the impact of green stimulus policies—as measured by GEPI—on the speed and nature of the economic recovery and the extent to which the green stimulus was successful in accelerating the transition to a low-carbon economy. We leave this for future research. However, to glean intuition from the limited number of countries in this analysis, we present scatter plots showing the correlation between the GEPI and several co-variates of interest.

4.3. Correlational analysis

Fig. 3 shows that richer countries have greener recovery packages. This is consistent with the theory that environmental quality is a normal good and the environmental Kuznets’ curve hypothesis (Dinda, 2004). However, there is no statistically significant relationship between the

---

15 The PCA methodology does not specify which variables should enter positively or negatively into the index. However, these magnitudes suggest another means for constructing an index, which would lead to similar conclusions. For example adding the normalized variables with either a negative or positive sign depending on whether they support fossil fuels.

16 In the wake of the GFC, South Korea spent 80% of their 45 billion USD economic recovery package on green investments. This was part of a broader National Green Growth Strategy.
growth rate of the real GDP and GEPI. The fast-growing, emerging economies of China and India have above-average GEPI scores, whereas other fast-growing economies, such as Turkey and Indonesia, have lower scores. There is no discernible relationship between the current emission intensity and the GEPI holds even after we condition on GDP/capita. Furthermore, some countries have high emission intensities, such as India and China, and higher-than-average GEPI scores. Future research could explore whether green stimulus in these countries contributed to lowering emission intensity over time, and whether the compositional effect of an economy (i.e., economies with a higher proportion of low emissions service sectors versus emissions intensive manufacturing and primary extraction-based economies) may influence the negative correlation. Finally, Fig. 3 shows that there is a weak relationship between the GEPI and the share of renewable energy used in consumption. We show in the Supplementary Materials that the slopes of the regression lines shown in Figure 3 are statistically significant for emissions intensity and GDP per capita. After conditioning on GDP per capita, the negative relationship with emissions intensity is insignificant and the relationship with the share of renewables in consumption becomes significant. We show in the Supplementary Materials that the slopes of the regression lines shown in Figure 3 are statistically significant for emissions intensity and GDP per capita. After conditioning on GDP per capita, the negative relationship with emissions intensity is insignificant and the relationship with the share of renewables in consumption becomes significant.

Table 3

Principal components analysis.

|         | Eigenvalue | Difference | Proportion | Cumulative |
|---------|------------|------------|------------|------------|
| PCI     | 2.93       | 1.55       | 41.8%      | 41.8%      |
| PC2     | 1.38       | 0.03       | 19.7%      | 61.5%      |
| PC3     | 1.34       | 0.48       | 19.2%      | 80.7%      |
| PC4     | 0.87       | 0.61       | 12.4%      | 93.1%      |
| PC5     | 0.26       | 0.13       | 3.7%       | 96.8%      |
| PC6     | 0.13       | 0.04       | 1.9%       | 98.7%      |
| PC7     | 0.09       | 1.4%       | 100%       |            |

Table 4

Country ranking by GEPI.

| Country         | Rank | GEPI | Low Carbon | Fossil Cond. | Fossil | Low Carbon | Fossil Cond. | Fossil | EPT Spend./Cap. (USD) |
|-----------------|------|------|------------|--------------|--------|------------|--------------|--------|----------------------|
| France          | FRA  | 2.96 | 52%        | 22%          | 10%    | 50%        | 25%          | 25%    | $1,077               |
| Canada          | CAN  | 2.65 | 49%        | 16%          | 24%    | 36%        | 3%           | 46%    | $2,223               |
| Germany         | DEU  | 2.51 | 38%        | 15%          | 23%    | 57%        | 43%          | 0%     | $841                 |
| Italy           | ITA  | 2.50 | 89%        | 1%           | 7%     | 87%        | 7%           | 7%     | $924                 |
| United Kingdom  | GBR  | 1.35 | 45%        | 2%           | 46%    | 66%        | 6%           | 19%    | $1,230               |
| European Institutions | EU  | 0.87 | 22%        | 0%           | 0%     | 0%         | 100%         | 0%     | $39                  |
| Japan           | JPN  | 0.51 | 92%        | 0%           | 8%     | 0%         | 0%           | 50%    | $165                 |
| India           | IND  | 0.29 | 25%        | 4%           | 25%    | 51%        | 7%           | 28%    | $109                 |
| Australia       | AUS  | 0.14 | 55%        | 4%           | 28%    | 24%        | 6%           | 59%    | $231                 |
| Republic of Korea | KOR | 0.07 | 21%        | 0%           | 78%    | 100%       | 0%           | 0%     | $123                 |
| China           | CHN  | –0.18| 31%        | 3%           | 38%    | 43%        | 7%           | 43%    | $47                  |
| Brazil          | BRA  | –0.47| 24%        | 0%           | 15%    | 12%        | 4%           | 40%    | $18                  |
| Mexico          | MEX  | –1.05| 19%        | 0%           | 81%    | 29%        | 21%          | 43%    | $78                  |
| Indonesia       | IDN  | –1.19| 04%        | 0%           | 96%    | 40%        | 0%           | 10%    | $25                  |
| United States   | USA  | –1.40| 27%        | 0%           | 73%    | 8%         | 8%           | 77%    | $301                 |
| Turkey          | TUR  | –1.40| 1%          | 0%           | 99%    | 46%        | 8%           | 38%    | $168                 |
| Saudi Arabia    | SAU  | –1.60| 0%          | 0%           | 100%   | 50%        | 0%           | 50%    | $161                 |
| South Africa    | ZAF  | –1.60| 0%          | 0%           | 100%   | 23%        | 9%           | 27%    | $11                  |
| Russia          | RUS  | –2.19| 0%          | 0%           | 100%   | 10%        | 0%           | 60%    | $36                  |
| Argentina       | ARG  | –2.77| 0%          | 0%           | 99%    | 0%         | 0%           | 100%   | $30                  |

This table shows ranks of countries by the value of their GEPI. A higher GEPI means “greener” stimulus based on both dollar spending and other non-monetary measures that directly affect energy production and consumption. The table also shows the values of the underlying variables used in the GEPI construction. Spending Share refers to the share of total spending allocated to the low-carbon, fossil-conditional, and fossil-unconditional policies. Non-Spending Policy # Share refers to the fraction of the total number of non-spending policies in each classification. EPT Spend./Capita is the overall spending per person for each country in the Energy Policy Tracker (2021) dataset. The index is constructed based on data from January 2020 to December 2021.
Fig. 3. Correlation analysis (1).
All four panels have the GEPI on the vertical axis. The top left panel shows the relationship with the log of GDP/capita (2018). The top right panel shows the average real GDP growth from 2010–2018. The bottom left panel shows the relationship with the emission intensity, measured in megatons of CO₂ equivalent per billion USD of GDP. The bottom right panel shows the relationship between the GEPI and the share of renewables used in consumption. The real GDP per capita and real GDP growth rates are from the World Bank Open Data Archive.

Fig. 4 captures the relationship between the GEPI and the overall policy response to COVID-19 using data from Elgin et al. (2020) based on the IMF Policy Tracker. We replicate their COVID-19 Economic Policy Index (CEPI) using a PCA analysis including variables related to the fiscal, monetary, and balance-of-payments responses of G20 countries. We find that there is a positive relationship between the two indices. This means that countries that have a strong green stimulus response to COVID-19 have a strong overall economic stimulus response to the crisis. Next, we include three variables that reflect the severity of the crisis. The first, in the top right panel of Fig. 4, depicts the severity of the economic crisis defined as the maximum quarterly year-over-year percentage decline in economic activity in the first three quarters of 2020. For most economies, this occurred in the second quarter. However, for China, it was in the first quarter. The bottom left panel shows the number of COVID-19-related deaths per 100,000 as of December 31, 2020. The correlation between the measures of the severity of the crisis and the GEPI is slightly positive. There is some evidence that the countries that experienced the crisis more acutely had greener responses. However, the bottom right panel shows that the correlation is strongest between the GEPI and the share of the population over 65 years, as proxy for countries’ vulnerability to COVID-19. We show in the Supplementary Materials, Table A.2, that this relationship is statistically significant even after controlling for GDP per capita. However, including both GDP per capita and the population share causes the GDP per capita measure to be insignificant. This may be due to collinearity between the two variables.¹⁸

All four panels have the GEPI on the vertical axis. The top left panel shows the relationship with the log of GDP/capita (2018). The top right panel shows the average real GDP growth from 2010–2018. The bottom left panel shows the relationship with the emission intensity, measured in megatons of CO₂ equivalent per billion USD of GDP. The bottom right panel shows the relationship between the GEPI and the share of renewables used in consumption. The real GDP per capita and real GDP growth rates are from the World Bank Open Data Archive.

5. Discussion

While it is too early to assess the efficacy of green stimulus measures introduced in response to the COVID-19 crisis, the current study offers useful insights on countries’ initial responses to the pandemic and to what extent they may have used the crisis to advance their climate goals. In particular, the proposed GEPI measures provides a comprehensive index that can be used in future studies. We also note several limitations that can be addressed in future research. First, our dataset includes government spending commitments publicly announced in their stimulus packages. At this time, we are unable to track the disbursements of these commitments to assess whether the intended spending has materialized. Some of the commitments will be spread out over several years, while others are immediate. These differences are important to determine the appropriate time frame when studying the potential impact of green stimulus on future outcome variables, such as those related to emissions or other environmental performance indicators.

Second, one could argue that any effort to categorize stimulus based on policy-makers’ intentions is susceptible to claims of green washing. However, given the internal review process that was used to classify these policies within EPT and our efforts to analyze these policies line by line in our own classification, we are confident that they present a good proxy of various degrees of “greenness” that enable reasonable comparisons between countries. On the other hand, we acknowledge that in some country cases, prioritizing green stimulus policies can be the results of the current economic structure where aid is simply flowing to dominant sectors that are already low-carbon. Further investigation of how the base-level carbon intensity affects the GEPI may offer useful insights on this question.

Another issue is that some measures in the EPT dataset have not been assigned dollar values. This is because their costs have not been publicly announced. As more data becomes available from future government updates, it will be easy to revisit the data and adjust our GEPI calculation to reflect the new information. We have checked the robustness of our
index to the exclusion of non-spending policies. None of the results in the paper are sensitive to this robustness exercise. Lastly, some of the commitments that we track may have been in preparation before the pandemic. However, this does not undermine the rationale for including them, as governments had the option to delay these measures if they had other priorities in their stimulus packages. Another limitation related to the data is that only policies that directly impact energy supply and demand are documented in the EPT database. This means that unconditional transfers to households are excluded, even though they may impact energy demand indirectly through increased incomes.

In the current analysis, we did not fully exploit the richness of subnational data. Although these policies have been included in the corresponding country indices, they can be used separately to reveal within-country differences, which can be significant for some countries, such as Canada, where provinces have different environmental policies. Additionally, we acknowledge some limitations related to our correlational analysis. We do not claim that the studied relationships between variables, such as income per capita and the GEPI, are causal and we recognize the need to control for confounding variables which may mitigate the results described above. For example, rich countries tend to have lower emission intensities. We attempt to investigate these issues by running various regression analyses in the Supplementary Materials to illustrate how we can improve the empirical model as the number of countries covered in the EPT increases and economic and environmental performance data post-pandemic become available. In addition, future analyses should explore other country characteristics, especially those reflecting environmental policies at different stringency levels, such as the use of a carbon tax, emission trading systems, other environmental policy indicators, and political factors measuring pro-environmental attitudes of different political parties that implemented recovery policies.

Finally, two studies were published at the time of finalizing this paper. Vivid Economics, a think tank, created an index of the environmental impact of the policy responses to the COVID-19 crisis (VIVID, 2020). Their index is different from our GEPI as it only relies on data regarding fiscal policies (i.e., government spending and procurement) whereas we use the EPT data on all fiscal, monetary, and regulatory policies related to energy supply and demand. In addition, our index has a cardinal interpretation, which means that it can be used in future ex-post regression analyses as shown in the Supplementary Materials. The Vivid Economics index has a strictly ordinal interpretation making it difficult to interpret correlations between the index and economic outputs, population, or the severity of the COVID-19 crisis. Nonetheless, our index tracks theirs closely in terms of the ranking of countries, and we can extend their analysis in interesting new directions.

The Oxford Global Recovery Observatory is another ongoing data creation effort that seeks to classify fiscal stimulus in response to the COVID-19 crisis (O’Callaghan and Murdock, 2021). Their analysis, based on various policy archetypes, also shows that the level of development of a country is positively related to the size and greenness of the economic recovery (they do not create an index that measures the greenness of stimulus). We see our work as complementary to the Oxford Observatory, with a particular focus on policies that affect energy supply and demand. In future revisions of our GEPI, we will include any useful data from the Observatory and other sources to crosscheck information from the EPT.

--

19 Specifically, we re-compute the GEPI index using only the three spending share components as well as EPT spending/capita. This new index has a correlation of 0.94 with the index reported in this paper. The Spearman rank correlation is 0.95. The correlations presented in Figures 3 and 4 are unchanged.

20 We compare the two indices in the Supplementary Materials (Table A.4) and find that the Spearman rank correlation between the two is 0.85 (p-value = 0).
and enhance our methodology. These parallel studies provide useful references for additional correlation analyses using our GEPI.

6. Conclusion

This paper analyzes countries’ differences in their response to the COVID-19 crisis and the extent to which they have used this crisis as an opportunity to advance green spending and climate-friendly policies in their stimulus packages to accelerate the transition net-zero. We use a unique dataset, the EPT, which includes fiscal stimulus and other pandemic-related policies and regulations that have an impact on the production and consumption of energy across multiple sectors. Our analysis covers the G20 countries’ policies between January 2020 and December 2021. During this period, G20 countries committed unprecedented spending amounts and other measures that could have a significant impact on the global energy transition, as these countries are jointly responsible for more than two-thirds of global emissions.

Based on the EPT data, we categorize the stimulus policies publicly announced by the G20 countries into low-carbon, fossil-conditional and fossil-unconditional policies. We propose a new measure, the Green Energy Policy Index (GEPI), accounting for both “green” and “brown” stimulus policies and adjusting for the total size of the energy-related response package in a given country. Our index, using Principle Components Analysis, is easy to interpret and captures the cross-country differences in terms of the greenness of their stimulus packages in response to the COVID-19 crisis. We then look at the correlation between the GEPI and several country characteristics.

We document that on average, G20 countries have invested substantial resources in green stimulus measures that are likely to reduce GHG emissions as these countries emerge from the pandemic. However, there are significant variations between countries. The top three countries are France, Canada, and Germany, followed by Italy and the U.K. These countries also had the largest overall energy related stimulus packages, with spending between $841 and $2,223 USD per capita. This does not include central bank monetary stimulus and other facilities to increase market liquidity and improve the functioning of the financial system.

Our correlation analysis shows that richer countries have greener stimulus packages. The evidence is mixed regarding whether high-emission-intensity countries are using the crisis as a chance to build back better. Although this might be true for some countries, such as India and to a lesser extent, China, the top-ranked countries, by GEPI, with the exception of Canada, are those who started the pandemic with lower emission intensities. We find some evidence that countries that experienced larger declines in GDP and larger death rates from COVID-19 adopted greener stimulus packages. Additionally, we find that countries that had strong overall policy responses rank higher in terms of the GEPI.

Our framework for constructing the GEPI will be useful in ex-post analyses of the effectiveness of green fiscal stimulus, a topic not well understood in the academic literature and policy-making circles. The variation that we document can be used in empirical identification strategies as more countries become available in the EPT dataset and more information on new fiscal stimulus policies is included. This aggregate, cross-country analysis should be complementary to microeconomic program evaluation studies and ex-ante analyses. Given the relative lack of understanding of green fiscal stimulus, various research methods investigating the ex-post and projected effects would be useful to assess the effectiveness of post-COVID-19 green recovery policies in reducing emissions.

Despite the great momentum around the “build back better” debate that intensified at the onset of the COVID-19 pandemic (Zachariadis et al., 2021), our analysis suggests that the crisis may amplify existing disparities between countries and their trajectories to a low-carbon future. Overall, our findings could be used to implement greater accountability measures in jurisdictions lagging in low-carbon investments and design policy tools that will help redirect carbon-intensive spending (e.g., imposing border carbon adjustments).

Funding

The authors acknowledge financial support from the Social Sciences and Humanities Research Council (SSHRC) of Canada and the Pacific Institute for Climate Solutions (PICS).

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests. Basma Majerbi reports financial support was provided by Social Sciences and Humanities Research Council of Canada. Basma Majerbi reports financial support was provided by Pacific Institute for Climate Solutions.

Data availability

Our Data in Brief file includes a link to a Mendeley repository with all data files and R scripts.

Acknowledgment

The authors thank Merwan Engineer, Kristy Faccer, Michael King, Raahil Madhok, Felix Morency-Lavoie, Rashid Nikzad, Sarah Jacobson and Brandon Schaafle for helpful comments. We also thank participants from the UVic Economics Brown Bag Seminars, the Pacific Institute for Climate Solutions, the Canadian Economics Association Meetings, the Canadian Society for Ecological Economics Meetings and the Canadian Resource and Environmental Economics PhD and Early Career Scholars Forum. We are also grateful for valuable comments from four anonymous reviewers at Ecological Economics. All errors remain our own.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ecolec.2022.107586.

References

Agrawala, S., Dussaux, D., Mont, N., 2020. What policies for greening the crisis response and economic recovery? Lessons learned from past green stimulus measures and implications for the COVID-19 crisis. In: OECD Environment Working Papers No. 164. https://doi.org/10.1787/19970900.

Barbier, É., 2016. Green stimulus, green recovery and global imbalances. World Econ. 11, 149–177.

Barbier, É., 2020. Greening the post-pandemic recovery in the G20. Environ. Resour. Econ. 76 (4), 685–703.

Batini, N., Di Serio, M., Fragetta, M., Molina, G., Waldron, A., 2021. Building Back Better: How Big Are Green Spending Multipliers? IMF.

Caldecott, B., 2020. Post COVID-19 stimulus and bailouts need to be compatible with the Paris agreement. J. Sustain. Fin. Invest. https://doi.org/10.1080/20430795.2020.1809292.

Chodorow-Reich, G., 2019. Geographic cross-sectional fiscal spending multipliers: what have we learned? Am. Econ. J. Econ. Pol. 11 (2), 1–34.

Costanza, R., de Groot, R., Sutton, P., van der Ploeg, S., Anderson, S.J., Kubiszewski, I., Turner, R.K., 2014. Changes in the global value of ecosystem services. Glob. Environ. Chang. 26, 152–158. https://doi.org/10.1016/j.gloenvcha.2014.04.002.

Council of Economic Advisors, 2016. A Retrospective Assessment of Clean Energy Investments. Executive Office of the President of the United States.

Dippel, D., Doppelt, C., Marris, P., Menon, V., 2011. Fossil CO2 and GHG Emissions of all World Countries: 2019 Report. Publications Office of the European Union, Luxembourg. https://doi.org/10.2760/887800.

Elgin, C., Barbog, G., Yalaman, A., 2020. Economic policy responses to a pandemic: developing the COVID-19 economic stimulus index. Civid Econom. 46, 53.
Energy Policy Tracker, 2021, December 31. Energy Policy Tracker. https://www.energypolicytracker.org/.

Engler, Daniel, Groh, E., Gutsche, G., Ziegler, A., 2021. Acceptance of climate-oriented policy measures under the COVID-19 crisis: an empirical analysis for Germany. Clim. Pol. 1-17 https://doi.org/10.1080/14693062.2020.1864269.

Fatás, A., Summers, L.H., 2018. The permanent effects of fiscal consolidations. J. Int. Econ. 112, 238–250, https://doi.org/10.1016/j.jinteco.2017.11.007.

Giandomenic, L., Papineau, M., Rivers, N., 2020. A Systematic Review of Energy Efficiency Home Retrofit Evaluation Studies. Smart Prosperity Institute.

Golosov, M., Hansen, J., Krusell, P., Tsyvinski, A., 2014. Optimal taxes on fossil fuel in general equilibrium. Econometrica 82 (1), 41–88. https://doi.org/10.3982/ECTA10217.

Goulder, L.H., Parry, I.W., 2008. Rev. Environ. Econ. Policy 2 (2), 152–174. https://doi.org/10.1093/reep/ren005.

Harrison, K., 2010. The comparative politics of carbon taxation. Annual Rev. Law Soc. Sci. 6, 507–529. https://doi.org/10.1146/annurev.lawsocsci.093008.131545.

Hepburn, C., O’Callaghan, B.S., Stiglitz, J., Zenghelis, D., 2020. Will COVID-19 fiscal recovery packages accelerate or retard progress on climate change? Oxf. Rev. Econ. Policy 36 (Supplement 1), S159–S381. https://doi.org/10.1093/oxrep/graa015.

Heutel, G., 2012. How should environmental policy respond to business cycles? Optimal policy under persistent productivity shocks. Rev. Econ. Dyn. 15 (2), 244–264. https://doi.org/10.1016/j.recd.2011.05.002.

IEA, 2021. Net Zero by 2050: A Roadmap for the Global Energy Sector.

IPCC, 2018. Global warming of 1.5 °C. In: A IPCC Special Report. IPCC.

IPCC, 2021. Summary for Policy Makers: Climate Change 2021, the Physical Science Basis.

James, G., Witten, D., Hastie, T., Tibshirani, R., 2013. An Introduction to Statistical Learning with Applications in R. Springer, New York, NY. https://doi.org/10.1007/978-1-4614-7138-7.

Khatiwada, S., 2009. Stimulus Packages to Counter Global Economic Crisis: A Review. International Institute for Labour Studies, Geneva. Retrieved from. http://gesd.free.fr/dp19609.pdf.

Michaud, A., Rothert, J., 2018. Redistributive fiscal policies and business cycles. J. Int. Econ. 112, 123–133. https://doi.org/10.1016/j.jinteco.2018.02.003.

Mundaca, L., Richter, J., 2015. Assessing ‘green energy economy’ stimulus packages: evidence from the US programs targeting renewable energy. Renew. Sust. Energy, Rev. 42, 1174–1186. https://doi.org/10.1016/j.rser.2014.10.060.

NGFS, 2020. Statement on the Need for a Green Recovery out of the COVID-19 Crisis. Network for Greening the Financial System, Paris.

OECD, 2020, December 31. Quarterly National Accounts. Paris. Retrieved from. http://stats.oecd.org/.

OECD, 2021. Net Zero by 2050: A Roadmap for the Global Energy Sector.

Pindyck, R.S., 2019. The social cost of carbon revisited. J. Environ. Econ. Manag. 94, 140–166.

Popp, D., Vona, F., Marin, G., Chen, Z., 2020. The Employment Impact of Green Fiscal Push: Evidence from the American Recovery Act. NBER.

Rees, W., 2010. Decarbonization under green growth strategies? The case of South Korea. J. Clean. Prod. 123, 180–193. https://doi.org/10.1016/j.jclepro.2015.08.060.

Ramey, V.A., 2019. Ten years after the financial crisis: what have we learned from the renaissance of fiscal research? J. Econ. Perspect. 33 (2), 89–114. https://doi.org/10.1257/jep.33.2.89.

Rhodes, E., Scott, W.A., Jaccard, M., 2021. Designing Flexible Regulations to Mitigate Climate Change: A Cross-Country Comparative Policy Analysis.

Robins, N., Clover, R., Singh, C., 2009. A Climate for Recovery: The Color of Stimulus goes Green. HSBC Global Research. Retrieved from. https://www.globaldashboard.org/wp-content/uploads/2009/HSBC_Green_New_Deal.pdf.

Sonnensthein, J., Mundaca, L., 2016. Decarbonization under green growth strategies? The case of South Korea. J. Clean. Prod. 123, 180–193. https://doi.org/10.1016/j.jclepro.2015.08.060.

Strand, J., Toman, M., 2010. Green stimulus, economic recovery, and long-term sustainable development. In: World Bank Policy Research Working Paper No. 5163. VIVID, 2020. Greenness of Stimulus Index. VIVID Economics.

Vyas, S., Kumaranayake, L., 2006. Constructing socio-economic status indices: how to use principal components analysis. Health Policy Plan. 21 (6), 459–468. https://doi.org/10.1093/heapol/czl029.

Vonprecht, B.S., Stiglitz, J., Zenghelis, D., 2020. Are we Building Back Better? UN Environment Program.

Worldometers, 2020. Worldometers Coronavirus Update (Live). Retrieved December 31, 2020, from. https://www.worldometers.info/coronavirus/.

Zachariadis, T., Giannakis, E., Taliatos, C., Karmellos, M., Fylaktos, N., Howells, M., Hallegatte, S., 2021. Building Back Better in Practice. World Bank.