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What policies for greening the crisis response and economic recovery? Lessons learned from past green stimulus measures and implications for the COVID-19 crisis

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WHAT POLICIES FOR GREENING THE CRISIS RESPONSE AND ECONOMIC RECOVERY?

LESSONS LEARNED FROM PAST GREEN STIMULUS MEASURES AND IMPLICATIONS FOR THE COVID-19 CRISIS - ENVIRONMENT WORKING PAPER N°164

By Shardul Agrawala, Damien Dussaux and Norbert Monti (1)

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Keywords: Stimulus package, environmental policy, policy evaluation, policy design, green growth

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Abstract

This paper evaluates green stimulus packages that were introduced in response to the global financial crisis (GFC) of 2007-08 and draws lessons relevant for greening the recovery from the Coronavirus (COVID-19) crisis. The paper underscores the importance of building in policy evaluation mechanisms into green stimulus measures. It also provides evidence that the implementation of sufficiently large, timely and properly designed green stimulus measures can generate economic growth, create jobs and bring about environmental benefits. However, there are also trade-offs between competing economic, environmental and social policy objectives, which underscores the importance of proper policy design.

The paper also highlights key differences between the GFC and the COVID-19 crises and how these differences might influence the green stimulus in the present context. The public health priority to prevent the COVID-19 crisis from worsening is to severely restrict many economic activities that could escalate virus transmission. In this context, green measures could initially have a "do no harm" orientation by maintaining vigilance against environmental rollbacks and ensuring that any measures taken to address the crisis do not inadvertently exacerbate environmental impacts. Green stimulus would become more relevant as the recovery begins, but these measures would need to be adapted to current social priorities such as the environment-health nexus, concerns about a "just transition", as well reflect shifts in social preferences. COVID-19 is also unfolding in a policy context that is very different from 2007-08. Costs of renewable energy have witnessed dramatic declines, while new environmental issues like resource efficiency and the transition to a circular economy have risen on the policy agenda. These developments offer new impetus and opportunities for greening the recovery in the wake of the COVID-19 crisis.

Keywords: Stimulus package, environmental policy, policy evaluation, policy design, green growth

JEL codes: E61, E62, E65, O44, Q58

Résumé

Ce papier évalue les plans de relance verte qui ont été introduits en réponse à la crise financière mondiale (CFM) de 2007-08 et tire des enseignements pertinents pour rendre plus écologique la relance économique en réponse à la crise due au coronavirus (COVID-19). Le papier souligne l'importance d'intégrer des mécanismes d'évaluation des politiques publiques dans les mesures de relance verte. Il montre également que la mise en œuvre de mesures de relance verte suffisamment importantes, opportunes et bien conçues peut générer une croissance économique, créer des emplois et avoir des effets bénéfiques sur l'environnement. Cependant, le papier met en évidence des arbitrages entre des objectifs économiques, environnementaux et sociaux concurrents, ce qui souligne l'importance d'une conception adéquate des politiques publiques.

Le papier souligne également les principales différences entre la CFM et celle de COVID-19 et la manière dont ces différences pourraient influencer le plan de relance verte dans le contexte actuel. La priorité de santé publique pour empêcher l'aggravation de la crise de COVID-19 est de restreindre sévèrement de nombreuses activités économiques qui pourraient augmenter la transmission du virus. Dans ce contexte, les mesures de relance verte pourraient initialement consister à "ne pas nuire" à l'environnement en maintenant la vigilance contre l'assouplissement des réglementations environnementales et en veillant à ce que toute mesure prise pour faire face à la crise n'aggrave pas involontairement les impacts environnementaux. Les mesures de relance verte deviendraient de plus en plus pertinentes à mesure que la relance économique s'amorcerait, mais elles devraient être adaptées aux priorités sociales actuelles, telles que le lien entre l'environnement et la santé et les préoccupations relatives à une "transition juste", et refléter les changements dans les préférences sociales. La crise de COVID-19 se déroule également dans un contexte politique très différent de celui de 2007-08. Les coûts des énergies renouvelables ont connu une baisse spectaculaire, tandis que de nouvelles questions environnementales, telles que l'efficacité des ressources et la transition vers une économie circulaire, ont pris de plus en plus d'importance dans l'agenda politique. Ces évolutions offrent un nouvel élan et de nouvelles possibilités pour rendre la reprise suite à la crise de COVID-19 plus écologique.

Mots clés: Plan de relance, politique environnementale, évaluation des politiques publiques, conception des politiques publiques, croissance verte

Classification JEL: E61, E62, E65, O44, Q58

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Executive Summary

Concomitant with the announcement of policy measures to respond to the Coronavirus (COVID-19) crisis there have been growing calls to ensure that such measures integrate responses to address a number of pressing environmental challenges. These developments are reminiscent of the widespread calls for greening the stimulus and recovery packages in the wake of the 2007-08 global financial crisis (GFC). Over 16% of all GFC related fiscal stimuli (totalling over half a trillion USD) were directed at green activities targeting renewable energy generation, energy efficiency in buildings, scrappage payments for vehicles with low fuel efficiency, clean technology development support, mass transit, nature conservation and water resource management. Many of these measures are also being proposed in the context of greening the COVID-19 recovery.

This paper examines what can be learnt from available evaluations of the impact of the green elements of stimulus packages introduced in response to the GFC that is relevant for the current context. A second objective of this paper is to examine how contextual differences between the current crisis and the GFC are also relevant for the orientation, design and timing of measures to green the COVID-19 recovery.

Lessons on green stimulus from the global financial crisis

Despite the magnitude of the overall investment, and the fact that a dozen years have elapsed since the GFC, this paper finds a remarkable dearth of evaluations of the macroeconomic, labour market and environmental effects of the green stimulus measures. Available evaluations also primarily tend to be ex ante, relying often on strong and, at times, opaque, assumptions. Ex post evaluations are relatively scarce and face the difficult task of defining a suitable counterfactual against which the impacts can be compared. A key lesson from the GFC is the need for systematically building in evaluation frameworks with clear criteria and robust methodologies into green stimulus measures in response to COVID-19. The distributional consequences of green stimulus measures should also be more explicitly considered in such evaluations.

This paper provides evidence that the implementation of sufficiently large, timely and properly designed green stimulus measures, which are well-embedded into domestic policy settings, can deliver economic and environmental benefits. At the same time, the paper also reveals the potential trade-offs between competing economic, environmental and social policy objectives. These trade-offs call for whole-of-government co-ordination to identify and mitigate potential divergence in the achievement of different policy objectives. Some green measures, for example in the Korean Green New Deal of 2009, had a positive impact on the economic recovery but had unclear environmental benefits. Others, like the US Car Allowance Rebate System or "Cash-for-Clunkers" programme, contributed to reduction of CO_2 emissions but had limited impact on economic growth and had a cost per job that was significantly higher than alternate stimulus measures. A more general lesson from the ex post evaluation of green stimulus measures during the GFC is that proper policy design is critical to prevent rebound effects, limit market distortion, and ensuring additionality of public funding by improved targeting. Flanking policy instruments that target underlying environmental externalities are also key to delivering greater environmental benefits from green stimulus investments.

Tailoring green recovery packages to the specificities of the COVID-19 crisis

The broad lessons from the GFC remain relevant for greening the COVID-19 recovery. At the same time, specific proposals to green the COVID-19 stimulus cannot simply be a “cut and paste” from the GFC playbook. The current crisis, triggered by a global pandemic, is fundamentally different. It has been accompanied by a very significant loss of human life which continues to climb; a tremendous strain on public health and social infrastructure; and significantly higher economic and social consequences worldwide that continue to unfold. While a key element of past crisis responses was to give an adrenalin shot to jumpstart economic activity, the fundamental public health priority to prevent the COVID-19 crisis from worsening is to severely restrict many economic activities that could escalate virus transmission.

An immediate priority, therefore, is to deal with the public health aftermath of the crisis and its continued toll on society. In this context, green measures could have a “do no harm” orientation and include maintaining vigilance on any rollback of environmental standards, ensuring that any scale-back or suspension of environmental management activities is temporary, and making sure that support measures put in place to restart the economy do not inadvertently exacerbate environmental damage.

Even when economies begin to recover, and they may do so on multiple speeds, society and societal priorities could undergo a significant change as a result of the devastating aftermath of COVID-19. These should be reflected in green stimulus measures as well. The nexus between public health and the environment, for example, will likely be a much higher public policy priority now compared with previous crises, especially given the emerging evidence of links between COVID-19 vulnerability and environmental stressors like air pollution. Concern about the social and distributional consequences is also likely to be paramount. Much more so than in the case of the GFC, to recover from the COVID-19 crisis, policy objectives towards a “just transition” and co-benefits of the health-environment nexus should be considered in green stimulus packages.

There could also be longer-term impacts of COVID-19 on societal preferences that could, in turn, lower the public acceptatibility of certain green measures like mass transit, while increasing demand for others, such as infrastructure for soft mobility. As growth picks up, governments will also have to ensure fiscal consolidation. In this context, they should consider whether and how environmental taxes and pricing of externalities can help create appropriate price signals as well as contribute to the reinvigoration of public finances.

Finally, COVID-19 is unfolding in a policy environment that is significantly different from 2007-08. The costs of key renewable energy technologies such as solar and wind have fallen dramatically since 2010 compared to other energy sources, making large scale financing more economically attractive. At the same time, measures such as green public R&D support could now target technologies that complement renewables but might be further from the market, such as energy storage. Another development since the GFC is the heightened attention to improving resource efficiency and the transition towards a more circular economy. Shifting away from unsustainable natural resource use would not only reduce environmental impacts and supply risks, it could also create job opportunities, for example in recycling, processing of secondary materials and repairing goods. Investments to support repairability, reusability, remanufacturing and recycling, largely absent in the green elements of the GFC stimulus, should also be considered as they can help support value creation and economic resilience. These developments offer new impetus and possibilities for greening the COVID-19 recovery.

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1. Introduction

As the world confronts the COVID-19 pandemic, caused by a novel coronavirus, governments are acting decisively to contain the public health crisis and its immediate social and economic fallout. The fiscal commitments announced by governments are extremely large, with a primary focus on providing liquidity to firms and income support to vulnerable households (OECD, 2020[1]). These responses are due to the unprecedented nature of the pandemic, how quickly the disease has transmitted globally, and the very heavy toll it continues to exact in terms of lives lost, strain on the public health infrastructure and other social services, partial unemployment and job losses and other economic strain due to lockdown measures.

The containment measures to address the public health crisis are themselves having very significant economic impacts. The OECD *Interim Economic Outlook* estimates that these measures could result in a decline of economic activity of 15-35% in some countries and a reduction in consumer spending by one-third (OECD, 2020[2]). Fiscal support measures are expected to shift gradually to addressing the adverse impacts of containment to adapt to the changing nature of the risk, notably from liquidity to solvency (OECD, 2020[1]).

The support measures will progressively be followed by the more conventional "fiscal stimulus" to support investment and consumption if growth is anaemic. Finally, once growth rebounds, the focus is expected to shift to fiscal and other measures to restore public finances (OECD, 2020[1]).

How and when countries transition from one stage to the next will be uneven given the differential impact of the (COVID-19) pandemic and its timing, and depending upon evolving national circumstances, all of which currently remain highly uncertain.

Concomitant with the announcement of policy measures to respond to COVID-19 there are also growing calls to ensure that such measures integrate responses to address a number of pressing environmental challenges as part of the eventual economic stimulus packages to put countries on the path to economic recovery (IEA, 2020[3]; OECD, 2020[4]). In their 15th of April 2020 Communiqué, the G20 Finance Ministers and Central Bank Governors also "commit to an environmentally sustainable and inclusive recovery … guided by a sense of shared, long-term responsibility for our planet and citizens, consistent with the 2030 Agenda for Sustainable Development, our national and local development strategies, and relevant international commitments" (G20, 2020[5]).

These developments are reminiscent of the widespread calls for greening the stimulus and recovery packages in the wake of the global financial crisis (GFC) of 2007-08. The case for "green growth", in fact, first gained widespread prominence following the GFC leading, among other things, to the adoption of the OECD's Green Growth Strategy in 2011 (OECD, 2011[6]). Indeed, green elements featured quite prominently in a number of stimulus and recovery packages that were implemented in the wake of the GFC, including in Korea, the United States, Japan, the EU and its Member States, and the People's Republic of China (China). It is estimated that approximately 16.3% (USD 521 billion) of all fiscal stimuli were green stimulus activities (HSBC, 2010[7]).[1] In the case of Korea, according to one estimate, the share was much higher and amounted to almost 80% of the stimulus measures in total (ILO, 2010[8]).

[1] As cited in ILO (2010[8]). Countries included in the HSBC (2010[7]) report are: Argentina, Australia, Canada, Chile, China, EU Member States, India, Indonesia, Japan, Korea, Mexico, Norway, Saudi Arabia, South Africa, Thailand, the United Kingdom, and the United States.

After a decade has elapsed since many of these measures were put in place, this paper examines what can be learnt from evaluations of the green elements of stimulus packages that were introduced in response to the GFC. Are there pointers in terms of target areas, the use of particular instruments and flanking measures, based on existing evaluations of such programmes?

The second objective of this paper is to offer some preliminary insights into how these lessons on greening the recovery are relevant to the current situation, taking into account both the commonalities and key differences between COVID-19, where the economic crisis is triggered by a global pandemic, and the global financial crisis.

The remainder of this paper is organised as follows:

Section 2 provides a brief overview of the toolkit of instruments that governments have used in previous crises, with a focus on green stimulus.

Section 3 reviews available peer-reviewed and other published literature on the evaluation of the green elements of the policy packages put in place in the wake of the GFC. Most of the evaluations focus on the relevant green packages in specific countries, or certain elements of those packages. A few studies do, however, compare certain green elements that were implemented across multiple countries.

Finally, Sections 4 and 5 conclude with key headline messages from the evaluation in the previous section and offer some observations about how these lessons could be relevant for the COVID-19 crisis – given its critical aspects that makes it different in fundamental ways from past crises of a financial and economic nature.

2. Elements of a green fiscal stimulus

Despite the fact that fiscal stimulus is a widely accepted measure to counter an economic downturn (together with other measures, most notably monetary policies like quantitative easing), the question arises about the effectiveness and the possible unintended consequences of such a stimulus. Thus, planning the timing and targeting of the stimulus package are of great importance (Elmendorf and Furman, 2008[9]). As in the case of quantitative easing, fiscal stimulus should also be temporary in nature. For instance, a permanent tax cut or spending measures without an end-date may lead to an eventual increase in budget deficit and increased levels of sovereign debt which, in turn, could restrain future investment.

Elements of a fiscal stimulus package can be categorised into unemployment benefits, transfers to low-income households, infrastructure spending, tax cuts, as well as additional measures to boost aggregate demand. The fact that the latter, miscellaneous, additional measures often take up a large portion of the stimulus packages highlights that targeting is often very specific to the economy in question. In addition, these packages frequently include not only fiscal components but also monetary elements, such as loan guarantees, which complicates categorisation of other stimuli. The differentiation between already existing fiscal packages and the further rescue efforts in the context of a stimulus can be difficult to tease out as well.

Most short-term fiscal stimulus measures have been concerned with boosting household and business spending through lowering taxes or providing tax rebates. These could target income, payroll or corporate taxes. Another measure may be a direct transfer to households, such as food vouchers, or the extension of unemployment benefits (either in time or in extent). Increased government spending not only has the direct benefit of increasing aggregate demand but it can also induce businesses to hire more workers to meet the increased demand and thus lower unemployment.

However, there remains the question of the need to balance the focus between the short-term and medium- to long-term policy measures and ensuring their effectiveness. While unemployment insurance, as well as food vouchers, along with transfers can be highly effective in the short run to boost demand, infrastructure and technological investments may not be as effective over a similarly short time period. Such investments often require additional planning and implementation, and therefore are seen as better for tackling recovery in the medium and long run. Many green packages are characterised by significant infrastructure and technological spending and therefore can constitute part of such a broader response.

Finally, as growth picks up, governments will also have to think about measures to ensure fiscal consolidation and put strained public finances back on a more healthy footing. These measures, if implemented too early, may cripple economic recovery by prematurely engendering strong austerity effects that would reduce aggregate demand. On the other hand, fiscal stimuli must be temporary in nature lest they affect long-term economic growth. Fiscal consolidation may include measures such as increasing various taxes, cutting government spending, reducing social security spending, or decreasing unemployment benefits and pensions. Distributional consequences of these fiscal consolidation measures should also be carefully examined.

What emerges from this very brief overview is the need for concerted and circumspect planning of fiscal stimulus packages. Well-targeted policies are essential to mitigate the worst impacts of the economic downturn. However, the subsequent weak growth will require stronger public investment. Such investment will be particularly fruitful in areas for which there are large positive externalities and in which under-investment is at risk of occurring due to market failures, including the environment.

Green stimulus

A green stimulus can be defined as "the application of policies and measures to stimulate short-run economic activity while at the same time preserving, protecting and enhancing environmental and natural resource quality both near-term and long-term" (Strand and Toman, 2010[10]). Indeed, the main aspect that differentiates a green stimulus from green policies in general is that it has the potential to be implemented more quickly, and its aim is to specifically respond to economic shocks, while also contributing environmental benefits (ILO, 2010[8]). Hence, stimulus measures should focus on economic activity in the short-run. However, the most effective short-run measures in terms of economic recovery often may not have an environmental aspect.

The typology of green stimulus measures is varied, and considerably tailored to the circumstances in which they are deployed. Generally speaking, green stimulus can be either *direct*, that is, spending is targeted at green activities and commodities, or *indirect*, where economic effects are felt through price mechanisms, where environmental tax revenues can be used to stimulate economic activity (green or not) by, for example, cutting labour taxes. Protection and restoration activities, such as building retrofits, as well as investment in traditional physical and human capital with an intention to significantly bring on environmental and climate change co-benefits, can also be seen as green stimulus measures (Strand and Toman, 2010[10]). In addition, the most common stimulus measures have been indirect –tax cuts, subsidies, as well as direct – infrastructure and spending programmes. Strand and Toman (2010[10]) identify motor vehicle taxes, tax exemptions for electric vehicles, and tax incentives for expenditures to improve the energy efficiency of buildings, as possible tax instruments. For general spending, large-scale support for R&D in low-carbon vehicles, cash-for-clunkers programmes, investment into renewable energy, and infrastructure investments have been most prominent. Table 1 shows the different categories of stimulus and their expected effect on growth, greenhouse gas (GHG) emission reduction and other environmental benefits.

Ensuring that environmental aspects are incorporated into the fiscal stimulus is not only viable but could also have major co-benefits. The underlying logic of using green stimulus, as opposed to one that does not have an environmental component is that the former is seen to be a "win-win" policy (Strand and Toman, 2010[10]). Introducing environmental aspects into the packages allows governments to make progress towards long-term environmental objectives, such as the transition to a low-carbon and resource efficient economy, while also providing a boost to economic activity in the shorter term.

Nevertheless, the nature and timing of policy packages must be carefully chosen. The short-term measures of the fiscal package should be fully focused on stabilising the economy and boosting economic activity by helping the most vulnerable households, by supporting the unemployed and by providing relief to small and medium-sized enterprises that are most at risk.

Short-term enactment of stricter green policies could potentially be seen as disconnected from reality and from the immediate social needs created by the economic downturn. Conversely, it can be tempting for governments and administrations to rush through environmentally damaging projects because they are ready to create short-term employment or to roll back existing environmental regulations. The green component of fiscal stimulus packages, given their technological and infrastructural nature, will often be more pertinent in the medium and long-term.

Table 1: Green stimulus measures and their anticipated effects

Stimulus	Expected effect: Short-term growth	Long-term growth	GHG emission reduction	Environment and resource co-benefits
Quickly implemented, labour-intensive activities				
Non-hazardous environmental recycling and clean-up	High	Low or Medium	Low	High
Natural resource monitoring and policing	Medium or High	Low	Variable	High
Energy efficiency retrofits	High	Medium	Medium	Medium
Capital Investments in environmental and natural resources				
Increased renewable electricity production	Low	Variable	High	Medium or High
Energy efficiency improvements in new capital	Low or Medium	Low or Medium	High	Medium
Green transport infrastructure, including mass transit	Low or Medium	Low	Medium or High	Medium or High
Other programmes				
Cash-for-Clunkers	Medium	Low	Low	Low or Medium
Power grid expansion	Low	Medium or High	Low or Medium	Variable

Note: Adapted from Strand and Toman (2010[10]).

3. Review of ex ante and ex post evidence of green stimulus packages following the global financial crisis (GFC)

Assessments of the macroeconomic, employment and environmental effects of green stimulus packages remain very limited. Available evaluations also primarily tend to be ex ante, relying often on strong and, at times, opaque, assumptions. Studies use vastly different evaluation methods, which makes direct comparison across studies difficult (Kammen, Kapadia and Fripp, 2006[11]).

One area of focus in ex ante evaluations of green stimulus measures is with regard to the impact of such measures on jobs, as boosting employment is a key policy priority in the wake of a crisis. The answer to this question, however, depends crucially on whether the employment effects being measured relate to direct jobs, or if they include indirect and/or induced jobs as well. Direct jobs can result from green investment in construction, installation, manufacturing, operations and maintenance and other activities. Indirect jobs include jobs in upstream supplier industries, while induced jobs gains or losses include economy-wide job reallocation effects (Harsdorff and Phillips, 2013[12]).

Spreadsheet-type computations can be used to calculate direct employment impacts by multiplying the ratio of employment per output by the additional output generated by the policy. For example, the number of working hours per solar panel installed is multiplied by the number of additional solar panels attributed to a policy supporting renewable energy sources. Total working hours are then converted into full time equivalents. Input-Output (I-O) models, meanwhile, are used to capture indirect employment effects. If a policy increases output in one sector, it is possible to use I-O tables to measure the impacts on output for the upstream sectors. Then, social and economic accounts are typically used to convert the change of output in change of employment. I-O frameworks, for example, have often been used to compute the impact of renewable energy development on job creation (Lambert and Silva, 2012[13]; Lehr et al., 2008[14]; Caldés et al., 2009[15]). They, however, fail to account for the dynamic, intertemporal general equilibrium effects of policy and thus the possible reallocation of jobs between industries. The latter can be analysed by computable general equilibrium (CGE) models that explicitly represent the role that prices play in determining supply and demand for products, commodities, and ultimately inputs such as labour (McCarthy, Dellink and Bibas, 2018[16]). These price mechanisms reflect economic feedback processes that generate the net economy-wide employment effects that take both job creation and destruction into account. However, as is the case with I-O models, CGE models often have significant data requirements, as well as being computationally demanding (Dixon and Jorgenson, 2012[17]). This paper presents employment effects as reported by the reviewed ex ante assessments, which use different methods, assumptions and data sources that are often not fully documented. Therefore, the ex ante estimates on employment creation cited throughout the paper should be interpreted with caution.

Ex post assessments of green stimulus programmes and projects are even more limited in number than ex ante assessments, and face a number of methodological challenges of their own. First, there is a question of whether the green stimulus has been *effective* in terms of environmental and jobs impacts. To address that question, it is necessary to identify a suitable control or counterfactual against which any ex post environmental, labour market, or economic impacts of green stimulus can be compared. The magnitude of stimulus packages also makes the construction of the counterfactual more difficult. The greater the stimulus, the more sectors are targeted, the more difficult it is to use non-targeted sectors as a control group because of the linkages between sectors in the economy. Many countries also triggered their GFC green stimulus programmes at the same time, making cross-country comparison challenging.

There are also opportunity costs of public money spent. Some stimulus measures are more cost-effective than others when their economic and environmental benefit per unit of public money spent is higher. In practice, assessing cost-effectiveness is also very difficult as the stimulus affects only a subset of the economic sectors or households and not all potential beneficiaries. Moreover, some programmes may appear cost-*in*effective in the short run but generate significant long-run gains through learning-by-doing and economies-of-scale.

Finally, greening the fiscal stimulus implies the targeting of multiple policy objectives. This further complicates policy evaluation as performance might vary across these multiple economic and environmental dimensions, and over different time horizons (short versus long-term).

Following this overview of some of the complexities faced in evaluating the impact of green stimulus measures, the remainder of this section reviews results from available ex ante and ex post assessments, first at the programme level across different environmental policy areas and then at the level of overall green recovery packages. This review mainly focuses on various fiscal stimulus packages put in place after the GFC. The narrative is complemented by available ex post evidence of the impact of similar measures that are relevant but not necessarily directly linked to the GFC stimulus. Such examples are presented in boxes so as not to distract, but rather to supplement, the overall green stimulus focussed narrative in this section.

Evaluation of green components in recovery packages

Renewable energy generation

For countries that implemented large green stimulus in response to the GFC, support for the generation of electricity from renewable energy sources made up a large proportion of green fiscal stimulus components.[2] The main rationale for public support of renewable-energy projects, beyond the twin-benefits created by a transition to a low-carbon economy and the possible net job impact in the short run, is that unit production costs decrease over time and with scale (Strand and Toman, 2010[10]). However, this rationale does not take into account that direct employment effects are often smaller because renewable-energy projects do not necessarily lead to increased domestic manufacturing, but rather to increased imports of equipment (Strand and Toman, 2010[10]).

The effect of USD 1 billion additional spending on renewable energy under the economic stimulus package of the Federal government of the United States was simulated in an ex ante assessment by Houser, Mohan and Heilmayr (2009[18]). The two schemes used for this simulation are the production tax credit (PTC) extension for power generated from wind energy, biomass, geothermal energy, municipal waste and hydropower, as well as increasing the investment tax credit (ITC) proportional to the investment of renewable capacity. Houser, Mohan and Heilmayr (2009[18]) found that the former would generate 39 100 jobs in the initial year and reduce CO_2 emissions by 728 kilotonnes (kt) annually during the 2012-20 period. The latter would generate

[2] Nevertheless, in the wake of the GFC, some countries like Spain experienced a drop in subsidies targeted to renewable energy.

33 300 jobs in the initial year, save USD 563 million in energy cost annually, and reduce CO_2 emissions by 213 kt annually.[3]

There have also been ex post assessments of the green stimulus programmes in response to the GFC. In the United States, solar electricity generation increased over 30 times from 2008 levels by 2015, and wind generation increased more than threefold (Council of Economic Advisors, 2016[19]). A significant part of this increase is attributed to the 2009 American Recovery and Reinvestment Act (ARRA) investments in the deployment of clean energy technologies, which also helped contribute to dramatic cost reductions for those same technologies as part of a virtuous cycle. For example, the overnight capital cost of utility-scale photovoltaic (PV) systems fell from USD 4.1/watt (W) in 2008 to USD 2.0/W in 2014—a decrease of 50%. Cost reductions for this and other technologies resulted from a number of factors—including economies of scale, technology learning, and new business practices—that were assisted by the widespread deployment made possible by ARRA (Council of Economic Advisors, 2016[19]).

ARRA also contributed to the creation of 26 600 jobs in the first years of its implementation. Official sources estimated that loan programmes targeting renewable energy systems and power transmission systems led to an annual reduction of 8.6 megatonnes (Mt) of CO_2 emissions. ARRA stimulus programmes are positively correlated with growth in a number of renewable energy technology patents issued by the US patent Office from 2009 to 2012 (Mundaca and Richter, 2015[20]), which was especially successful as patenting was facilitated by USPTO's Green Technology Pilot Program, accelerating the processing of green patents (Gattari, 2012[21]).

In addition, USD 46 billion of the USD 90 billion initial allocated to clean energy-related investments under ARRA leveraged over USD 150 billion in private and non-federal capital investment toward advancing the deployment of energy efficiency technologies (Council of Economic Advisors, 2016[19]). The ARRA experience demonstrates that public financing can be used to catalyse private investment without necessarily crowding out private finance. Clean energy manufacturing tax credit, with a total tax expenditure cap of USD 2.3 billion, supported 183 manufacturing facilities with a co-investment of as much as USD 5.4 billion while Clean Renewable Energy Bonds, by providing interest subsidies through the tax code, leveraged investment in renewable power for public and quasi-public utilities (Aldy, 2012[22]).

As regards employment effects, there is some ex post evidence that investing in renewable energy creates jobs, but studies also point to job destruction in other industries. Furthermore, subsidies diverted towards investment into renewables, if directed towards other sectors, could potentially lead to larger increases in employment (Box 3.1). These conclusions are more sobering than those from ex ante assessments that point to significant job creation potential. This probably stems from the general equilibrium effects of such policies not having been reflected in the ex ante estimates, leading to an upward bias in the expected job impacts. In any case, the employment effects cannot be viewed in isolation but in conjunction with the environmental benefits that renewable energy deployment would entail.

[3] The employment gains cited in this study are the direct jobs created multiplied by the Regional Input-Output Modelling System (RIMS-II) multiplier. Unlike a CGE framework, the study does not capture labour reallocation across sectors and the results should not be interpreted as net employment effects.

Box 3.1. Ex post evidence on renewable energy support and job creation

Evidence from ex post studies analysing public support to renewable energy, not necessarily as part of a green stimulus, is mixed regarding the impact of such measures on jobs.

Denmark is one of the countries with the greatest reliance on wind power relative to its full energy mix. For the period 2001-2005, yearly wind energy subsidies amounted to approximately EUR 230-350 million. In addition, there is substantial feed-in support via high electricity prices. However, government subsidies towards wind power generation in Denmark have shifted employment from more productive towards less productive sectors (Sharman, Meyer and Agerup, 2009[23]). This is because, in terms of value added per employee, the energy technology sector underperformed by as much as 13% compared with the industrial average over the period 1999-2006. Nonetheless, subsidies contributed to net real job creation of up to 10% of total employment in the Danish wind industry.

In the case of Spain, one study found that for each job created in the renewable-energy sector, two other jobs were lost to the economy between 2000 and 2008 (Álvarez, Jara and Julián, 2009[24]). To come to this conclusion, the authors compared the average annual productivity increase that the green job subsidy would have contributed to the economy had it not been consumed for public financing. This result also reflects the difference in energy production costs from renewables relative to production costs based on other energy sources.

Studies analysing the feed-in-tariff in Germany report mixed results in terms of job creation. One study highlights the importance of off-setting impacts such as job losses that result from the crowding out of cheaper forms of conventional energy generation and from the drain on economic activity precipitated by higher electricity prices (Frondel et al., 2010[25]). Another study based on macro-econometric modelling capturing some general equilibrium effect suggests an overall positive net employment effect of the expansion of renewable energy sources in Germany (Blazejczak et al., 2014[26]).

Energy efficiency in buildings

Poor infrastructure can commit countries to high levels of emissions for long future periods due to lock-in effects, as has been documented in various studies (Shalizi and Lecocq, 2009[27]; Strand and Toman, 2010[10]; World Bank, 2010[28]). Hence, there are theoretical grounds for investing in building energy efficiency.[4] Investing in building retrofits as well as new energy efficient buildings is also an interesting avenue for fiscal stimulus as it is labour-intensive and could contribute to job creation in the near term.

In the wake of the GFC several countries included significant amounts of resources towards energy efficiency in the larger stimulus packages. These included tax incentives, and grants for investing in insulation, installation of energy efficient lights, and retrofitting buildings. In Germany, subsidies for repairing residential houses amounted to EUR 3 billion. In France, EUR 960 million were invested in renovation of housing and public buildings, altogether. Austria's stimulus package concentrated on the energy efficiency of public buildings, and also

[4] There is, however, an interplay between the environmental benefits of investment in energy efficiency and the share of renewable-energy sources in the energy mix.

included tax reforms and stimulus packages that totalled EUR 100 million in energy-saving renovation. In Korea, a stimulus package worth USD 6 billion was spent to improve the energy efficiency of buildings. Canada's stimulus package of USD 238.5 million promoted energy efficiency improvements in residential buildings (ILO, 2010[8]).

In addition, investing in the installation of smart meters, providing feedback to energy consumers in the expectation that they will reduce their energy consumption, has also been considered in green stimulus packages. In the United States, the Smart Grid Investment Program, amounting to USD 3.5 billion of public spending in the ARRA, helped to support the installation of 16 million smart meters by 2016 (Council of Economic Advisors, 2016[19]).

One ex ante assessment indicates that infrastructure investments are well placed to yield both employment and environmental benefits. A USD 1 billion stimulus on smart metering was estimated to generate 40 000 jobs in the initial year, and lead to 207 kt of CO_2 emission reduction annually, as well as USD 918 million reduction in energy costs each year over the period 2012-20. USD 1 billion of spending invested in retrofitting buildings used by the Federal Government could have created 25 300 jobs in the initial year and reduce CO_2 emissions by 547 kt per year for the period 2012-20, whereas, the same amount spent on household weatherisation would have yielded 25 100 jobs in the initial year, and reduce CO_2 emissions by 441 kt annually over the 2012-20 period (Houser, Mohan and Heilmayr, 2009[18]).[5]

However, the ex post evidence regarding the evaluation of building energy efficiency stimulus in response to the GFC is scarce. One example is for the United Kingdom, where USD 137.9 million was allocated towards insulation and heating systems, with an additional USD 82.8 million spent on energy efficiency measures through the Decent Home programme, whereby every GBP 1 invested in the programme generated GBP 1.46 in social value (Nottingham Trent University, 2013[29]).[6] Estimates of the impact of these measures on jobs are however not provided.

Another ex post assessment was conducted by the Australian National Audit Office of the AUD 2.8 billion Home Insulation Program (HIP) that was a major part of the AUD 3.9 billion Energy Efficient Homes Package announced in February 2009 to generate economic stimulus and jobs in the construction industry. The audit concludes that HIP created between 6 000 and 10 000 jobs but that these jobs were "shorter lived than intended", while the energy efficiency benefits were "likely to be less than anticipated" (Australian National Audit Office, 2010[30]). The audit concludes that "overall HIP has been a costly programme for the outcomes achieved" and underlines "the critical importance of sound programme design and implementation practices to achieving policy outcomes" (Australian National Audit Office, 2010[30]).

Ex post assessments of investments in building energy efficiency beyond the specific context of the GFC stimulus also offer a mixed picture. For example, recent empirical literature shows that installation of smart meters can yield environmental benefits by decreasing in energy demand with effects that can persist at least for several months; but there may also be unintended consequences (Box 3.2).

[5] See footnote 3.

[6] In this study, social value captures the value of fewer home accidents, lower mental health issues, higher school attendance, lower fuel bills, reduced carbon emission, lower crime, higher local employment, etc.

Box 3.2. The effect of smart meters on energy consumption

There is econometric evidence that the information given by smart meters induce households to consume less energy. An econometric study analysing the effect of real-time feedback to electricity customers in Northern Ireland finds that the feedback results in 11–17% less electricity use and that the associated CO_2 emissions reductions are cost-effective (Gans, Alberini and Longo, 2013[31]). Another study using a random control trial on Google employees finds that access to feedback leads to an average reduction in household electricity consumption of 5.7%. Energy savings due to the feedback persist for up to one month (Houde et al., 2013[32]). However, the narrowness of this population makes it difficult to generalise the result of the study.

A more recent OECD study reviews the existing studies in the real-time information on consumer decision-making, as well as looks at the results of a study conducted in Ontario, Canada on a sample of 7 000 households which were provided with a smart meter (Rivers, 2018[33]). This study ultimately finds that there is a 3% decline in electricity use, sustained over a period of at least five months, which can be attributed to the use of in-home displays (IHD). Given that the decline appears to persist over time, the study provides some evidence that smart meters can be cost-effective over a sufficiently long period.

Although the installation of smart meters is generally perceived as highly expensive, a recent cost-benefit analysis (CBA) of the Smart Metering Implementation Programme in the United Kingdom finds a total net present value of GBP 6 billion over 2013-2034, with a reduction of carbon emissions by 45 Mt CO_2 (UK Department for Business, Energy & Industrial Strategy, 2019[34]).

Smart-metering, however, can also have unintended consequences. A recent study using data from a randomised-controlled trial on a sample of almost 2 500 Irish consumers examines the effect of smart-metering and residential feedback on household investment behaviour (McCoy and Lyons, 2017[35]). The study shows that exposure to time-of-use pricing and information stimuli, while reducing overall and peak usage, can also reduce investment in energy-efficiency measures within the home by 7.5 percentage points. This result highlights the need to have consistent policy measures in terms of investment in smart meters and building retrofits.

On the other hand, there is also some empirical evidence that the environmental benefits of investments in energy efficiency improvements may not increase in proportion to the size of the investment, or could be offset entirely, pointing to significant rebound effects in the behavioural response of home owners.[7]

Such mixed results from the existing energy-efficiency programmes targeting buildings may be more a consequence of the failure to account for behavioural responses to efficiency improvements in policy design. Hence, investments in energy efficiency improvements may need to be combined with measures such as dynamic data gathering on energy consumption to offset any rebound effects in energy demand. The question arises more so on the right policy mix, which

[7] For example, in a field experiment in Mexico, researchers found no detectable impact on electricity use or thermal comfort arising due to insulation or energy-efficiency upgrades (Davis, Martinez and Taboada, 2018[72]). Another empirical study in Maryland, USA concluded that that large rebates for the purchase of energy efficient equipment are not effective to reduce the energy consumption of households (Alberini, Gans and Towe, 2016[71]).

may require careful consideration and the rigorous review of existing evidence in combination with clear ex ante and corresponding ex post assessments, where such are possible.

Scrappage payments for vehicles with low fuel efficiency

As a response to the financial crisis, several countries also put policies in place that provided financial incentives to car owners to trade in their old, less fuel-efficient vehicles and buy new, more fuel-efficient vehicles. These scrappage payments for vehicles with low fuel efficiency were introduced in the wake of the GFC in many countries including Austria, Denmark, France, Italy, Japan, Germany, the Netherlands and the United States (ILO, 2010[8]).[8]

The most evaluated scrappage scheme is the US Car Allowance Rebate System (CARS) introduced in 2009, popularly known as the "Cash-for-Clunkers" programme. The CARS programme provided eligible consumers a rebate of USD 3 500-4 500 when trading in an old vehicle and purchasing or leasing a new vehicle and cost USD 2.85 billion in total (Li et al., 2013[36]).

An ex ante simulation conducted in 2009 concluded that a USD 1 billion spending on the US CARS programme would lead to the creation of 46 900 jobs, and reduce CO_2 emissions by 1 113 kt per year for the period 2012-20 (Houser, Mohan and Heilmayr, 2009[18]). These estimates suggest that the USD 2.85 billion programme would lead to the creation of 133 665 jobs and a reduction of CO_2 emissions by 3 172 kt per year.[9]

Ex post assessments of the CARS programme are more ambivalent. In the short run, the CARS programme helped maintaining employment in the car sector by preventing the sales of new vehicles to fall in the aftermath of the GFC. The programme provided rebates to 680 000 consumers (Li et al., 2013[36]), and led to roughly 500 000 purchases during the programme period (Green et al., 2016[37]). The liquidity provided by the CARS programme was critical for generating this large response from consumers (Green et al., 2016[37]). However, the overall economic impact was muted by the fact that programme simply pulled 370 000 vehicle sales forward as opposed to generating additional vehicle sales (Mian and Sufi, 2012[38]).

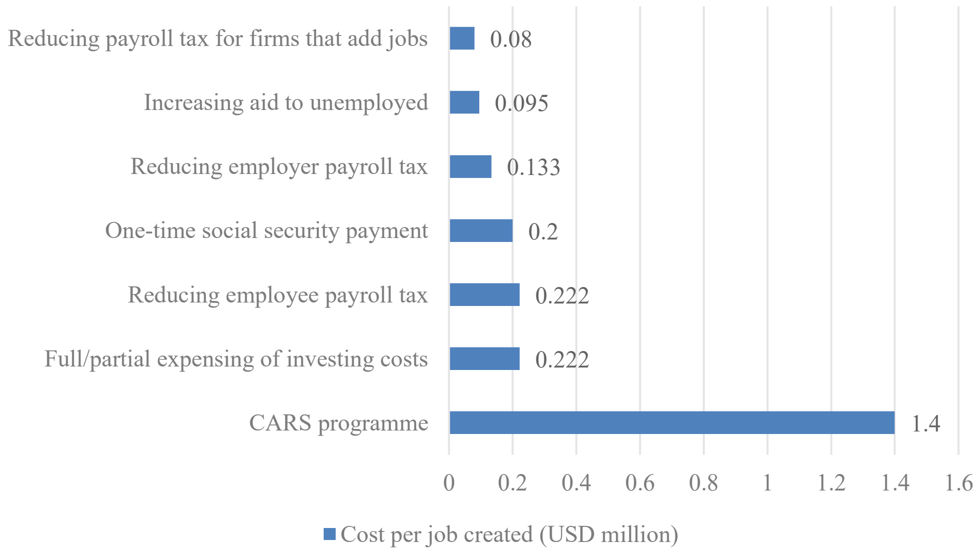
From an environmental standpoint, the CARS programme had a positive impact. An ex post study estimated that the CARS programme reduced CO_2 emissions by 9–28.2 Mt (Li et al., 2013[36]).

Nevertheless, the CARS programme was expensive given its impact on jobs and emission reductions. The cost per job created under the CARS programme was USD 1.4 million, which is much higher than alternative fiscal measures (see Figure 1) (Gayer and Parker, 2013[39]). In addition, the cost per tonne of CO_2 avoided of the CARS programme was estimated between USD 91 and USD 301, which is less cost-effective than renewable fuel standard (Gayer and Parker, 2013[39]). However, when compared to electric vehicle subsidies estimated to cost between USD 300 and 1 200 per tonne of CO_2 avoided, the CARS programme is more cost effective.

[8] In Germany, a scrappage payment of EUR 2 500 was provided to replace cars more than nine years old with new cars meeting EURO4 emission standards. The Italian scrappage payment was up to EUR 1 500. In France, the stimulus package promoted cars with low carbon emissions through a premium of EUR 1000 for vehicles emitting less than 160g of CO_2. In Japan, the scrappage program provided between USD 1 100 and USD 1 650 for the trade of old cars for new more fuel-efficient cars (ILO, 2010[8]).

[9] See footnote 3.

Figure 1: Cost per job created (USD million)



Source: Gayer and Parker **(2013[39])**

In addition to the CARS programme, other scrappage schemes such as the French *Prime à la casse* and the German *Umweltprämie* have also been evaluated (Pollitt, 2011[40]; OECD/ITF, 2011[41]). Similar to the CARS programme, these schemes were successful at maintaining car sales. It was estimated that scrapping premiums targeting low emission vehicles in Europe prevented car sales from decreasing by 30.5% (Grigolon, Leheyda and Verboven, 2016[42]).[10] Like in the US case, the European scrappage schemes brought forward the purchase of new vehicles rather than generating new purchases. For example, sales of motor vehicles in France also dropped significantly when the scheme ended in 2010 (OECD, 2016[43]).

However, the environmental impact of the scrappage schemes implemented in Europe are mixed. On the one hand, scrapping premiums targeting the purchase of low-emission vehicles were successful at reducing the average fuel consumption of new purchased cars. An econometric study by Grigolon, Leheyda and Verboven (2016[42]) estimates that targeted schemes in Europe increased the fuel efficiency of new purchased cars by 3.6%. On the other hand, scrappage schemes can generate rebound effects, wherein drivers of new, fuel-efficient cars drive longer distances because they save money on fuel expenditure. Scrapping premiums also had unintended environmental consequences. In Germany, lighter and smaller vehicles were traded in for medium-sized ones (OECD/ITF, 2011[41]). The French programme was successful in imposing a CO_2 limit on new vehicles, as well as retiring older cars, but the lifetime NO_X benefits were limited because the share of new diesel vehicles in total new-car purchases was greater than in the vehicles that were scrapped (OECD, 2016[43]). Over the longer run, such schemes could also risk perpetuating car dependency and delay the shift to more environmentally friendly modes of transport.

In addition, scrappage schemes face a number of challenges in terms of policy design. Scrapping premiums distort markets without addressing the underlying market failures. They are also not additional, but at times expensive substitutions for behaviour that would have happened anyway.

[10] Non-targeted scrapping schemes were as good as targeted schemes to maintain car sales.

For example, it has been estimated that 45% of the US CARS programme expenditure was targeted at consumers who would have made the purchase even in the absence of the programme (Li et al., 2013[36]). Moreover, these types of subsidies have distributional consequences as they cause discrimination between sectors of activity and between consumers, for example to the detriment of low-income households that cannot a buy new car even with the subsidy. Finally, their cost-effectiveness is not high as their cost can escalate quickly. In France, the scrapping premium cost more than EUR 1 billion rather than the EUR 220 million initially planned (OECD, 2016[43]).

Clean technology development support

Public support to technology development takes mainly two forms: direct government support to R&D activities and tax incentive support to R&D expenditure. Evaluating these measures is difficult as they can start bringing environmental and economic benefit only in the medium and long run. Many governments provided support to clean technology development as part of the response to the GFC (Pollitt, 2011[40]). For example, the United States and the EU provided USD 4.8 billion support to carbon capture and storage (CCS) projects.

An ex ante simulation conducted by Houser, Mohan and Heilmayr (2009[18]) estimated that USD 1 billion spending on CCS demonstration projects under the ARRA would generate 28 500 jobs in the initial year, reduce CO_2 emissions by 342 kt annually, and save USD 225 million per year in energy costs for the time period 2012-20.

Ex post, there is evidence that public support to CCS projects has overall not been successful so far.

In 2009, the European Union launched the European Energy Programme for Recovery (EEPR) to support key investments in the context of the economic crisis and in order to promote energy transition. One fourth of the programme funding was aimed at subsidising six carbon capture and storage projects for a total of EUR 1 billion of support. In 2018, only one project, providing operational small pilot facilities for capture, transport and storage, was finished. Yet, half of the planned support amounting EUR 424 million, was spent to support the projects. Three projects were terminated prematurely due to the decision of the project promoter not to invest, one project ended without completion and ROAD was the last remaining project (European Commission, 2018[44]).

The US experience was not successful either. ARRA authorised USD 3.4 billion support for CCS research and design, commercial demonstration, implementation, and education. In 2016, the US Department of Energy (DOE) returned USD 1.3 billion of the initial support to the US Department of Treasury for four CCS projects that were funded by DOE under the ARRA and were not able to advance given the ARRA funding timeframe (Council of Economic Advisors, 2016[19]).

This absence of success in CCS deployment within recovery packages reflects the significant challenges faced by businesses that are introducing innovative, early-stage energy technologies to markets but also that carbon prices were too low during the 2009-2020 period and therefore not pulling the market.

Nevertheless, not all CCS projects have been unsuccessful. A recent study analyses dozens of CCS demonstration projects that have been under development and identifies key parameters for success (Herzog, 2017[45]). First, successful CCS demonstration projects tend to occur in a region with a significant oil and gas industry. Second, it is important that CCS projects have access to carbon markets and electricity markets in addition to the Enhanced Oil Recovery (EOR) markets. Third, a performance standard limiting the amount of carbon emissions from coal-fired power plants allowed CCS to compete. Fourth, a well-designed regulatory environment to create business drivers is more successful than large government subsidies with little competition. The time limits of ARRA and EEPR were seen as arbitrary and thus detrimental to success. By contrast, multiple financing components and shorter timelines are key for effective CCS power projects. Finally, power projects based on integrated gasification combined cycle (IGCC) technologies have had a poor record because IGCC has proven to be uncompetitive with pulverised coal (PC) plants. Notably, the low price of natural gas made IGCC less competitive.

To conclude, direct public R&D support can create risks associated with "picking winners". To minimise this risk, governments should encourage competitive selection of investments that are likely to have the highest social return (OECD, 2010[46]). Well-designed public support can help the development of clean technologies (Box 3.3).

Box 3.3. Designing public R&D subsidies and R&D tax credit

There is a rich literature available on the possible effects of public R&D subsidies. Government R&D effort should focus on technologies that are upstream (or have a general purpose) and have a strong public good component such as energy storage, smart grids, energy efficiency and infrastructure for electric vehicles. For the public support to be effective, governments should implement environmental policies that increase the cost of polluting activities (Dechezleprêtre and Popp, 2015[47]).

Yet the question arises on the optimal magnitude of public R&D support. Given that there is no evidence of diminishing returns to energy R&D funding, there is still potential for increasing public R&D support to develop low-carbon technologies (Dechezleprêtre and Popp, 2015[47]). The increase in funding has to be gradual because the supply of researchers is fixed in the short run. In addition, clean R&D subsidies have to be integrated in a coherent national research policy.

Well-designed R&D subsidy programmes can increase employment and productivity and private R&D of targeted firms. In general, there is evidence that public R&D support may generate employment in R&D activities (Afcha and García-Quevedo, 2016[48]) and increase the productivity of firms (Cin, Kim and Vonortas, 2017[49]; Baghana, 2010[50]). Moreover, an econometric study using data on German SMEs shows that R&D subsidies increased R&D spending of targeted firms during the GFC (Hud and Hussinger, 2015[51]). While the existing empirical literature shows that the effectiveness of public R&D subsidies is mixed and depends on the characteristics of the subsidy programmes (Zúñiga-Vicente et al., 2014[52]), recent econometric evidence shows that R&D tax credit can generate statistically and economically significant effects on both R&D and patenting (Dechezleprêtre et al., 2016[53]). For instance, over the 2006-11 period, aggregate business R&D in the United Kingdom would be around 10% lower in the absence of the tax relief scheme.

Public transport

In light of the social distancing measures that have been put in place, public transport may have to be rethought. Likely, in the short term (until an effective vaccine becomes widespread), public transport will necessarily feature less prominently among the policy measures that could be taken to tackle the unfolding economic downturn that the COVID-19 health crisis has caused. Nevertheless, expanding public transport and greening it can *a priori* be seen as a highly effective green stimulus measure.

Ex ante, this is showcased by simulations that estimate that USD 1 billion additional spending on mass transit would generate 34 500 jobs in its initial year, with an additional 87 kt of CO_2 emissions reduced annually and USD 24 million saved per year in terms of energy costs for 2012-20 (Houser, Mohan and Heilmayr, 2009[18]).

There is no ex post assessment of mass transit stimulus in response to the GFC but the economic literature illustrates the economic benefits of public transport (Box 3.4).

Box 3.4. The economic benefits of investing in mass transit

Econometric analysis points to the possible effectiveness of expanding mass transit in job creation. In the United Kingdom, a decrease of 10% bus travel times were associated with a 0.13-0.3% increase in employment, *ceteris paribus* (Johnson, Ercolani and Mackie, 2017[54]). The extension of the San Francisco Bay heavy rail system led employers close to the line to hire Hispanic workers from deprived neighbourhoods (Holzer, Quigley and Raphael, 2003[55]). Many other studies using US data found a positive relationship between public transport and individual labour market outcomes (Yi, 2006[56]; Ong and Houston, 2002[57]; Cervero, Sandoval and Landis, 2002[58]).

In addition, investing in transport infrastructure affects positively labour productivity and long-run economic growth. An econometric study covering eighteen OECD countries from 1870 to 2009 found that the social rate of returns to investment in public transport infrastructure exceeds its private rate. A 10% increase in the share of the transportation infrastructure expenditure increases the labour productivity of the OECD countries by 0.14 percentage points (Farhadi, 2015[59]).

However, to reiterate, public transit may require careful rethinking, and may only be a viable green stimulus option once its role and safe use has been reimagined and implemented. Nevertheless, in the long-term, the essential role that public transport plays in several economies should be considered. Underinvestment and underutilisation of public transit would lead to significant economic and environmental strains. Therefore, investing into the quality of public transportation may indeed restore confidence towards this means of transport.

Nature conservation and water resource management

Other measures have also been taken in order to stimulate economic activity while improving environmental outcomes. As has been pointed out by previous studies, non-hazardous environmental clean-up, natural resource maintenance, monitoring and policing can be quickly implemented and are labour-intensive activities (Strand and Toman, 2010[10]). There are some ex ante assessments of the possible net job impact that such programmes may bring about. For instance, the Korean administration projected that river and forest restoration of Korea's "green stimulus" package would create 334 000 jobs for a spending of USD 12 250 million, while investment in dams in Korean rivers would create more than 16 000 jobs for a spending of USD 684 million (Barbier, 2009[60]).

This review has been able to find ex post assessments of the Korean Four Rivers Restoration Project that was part of the Korean Green New Deal (GND). The expenditure directed to water and green transport infrastructure under the GND provided a short-term boost to activity and employment but the environmental impacts of the Four Rivers Restoration Project were mixed (OECD, 2017[61]). On the positive side, the Four Rivers Restoration Project reduced the number of large floods, improved water quality and increased water availability. On the negative side, the project induced algae blooms, reduced the population of certain aquatic species, and adversely affected the habitats of several other species (Four River Restoration Project Investigation Evaluation Committee, 2014[62]; Board of Audit and Inspection, 2013[63]).

Overall ex post assessment of green recovery packages

Very few overall ex post assessments at the national green stimulus and recovery package have been performed. This review has so far been able to locate only two "third party" ex post assessments of national green stimulus packages in the wake of the GFC: i) US stimulus programmes targeting renewable energy (Mundaca and Richter, 2015[20]); and ii) Korea's Green Economic Stimulus, with a focus on energy sector (Mundaca and Damen, 2015[64]). In addition, the US Council of Economic Advisors published an evaluation of the clean energy investments in the ARRA (Council of Economic Advisors, 2016[19]) and the EU Commission has mandated their own evaluation of green elements of the recovery plans of nine European countries: Belgium, the Czech Republic, Estonia, France, Germany, Portugal, Slovakia, Sweden, and the United Kingdom (Pollitt, 2011[40]).[11]

Green Stimulus in the American Recovery and Reinvestment Act

It has been found that from a holistic perspective, the ARRA, passed in February 2009, was successful in stimulating the renewable energy sector (Mundaca and Richter, 2015[20]). Projects specific to ARRA were an important component of growth in renewable-energy capacity. It proposed a clean energy and green component of USD 92 billion, of which USD 21 billion was channelled towards renewable energy. Elements of the programme included: basic research programmes, such as the Advanced Research Projects Agency – Energy (ARPA-E); production tax credits (PTC) and investment tax credits (ITC); cash grants for renewable energy properties (the 1603 program); a tax credit for clean energy manufacturing (48C); targeted loan guarantees (the 1705 program); training programmes; and the Green Technology Pilot Program for faster patent processing.

There is evidence, albeit imprecise, of the effectiveness of these programmes: renewable energy capacity was increased by almost 27.1 gigawatts (GW) under the 1603 programme and 6.1 GW under the 1705 program, and 3533 green patents had been processed by 2012. These numbers, of course, do not account for what the developments would have been in a counterfactual scenario. CO_2 emission reduction was officially estimated at 8.6 Mt under the 1705 programme, while other sources estimated that the combined effect of diverse renewable energies led to 34-270 Mt declines in CO_2 emissions compared with business-as-usual (BAU), highlighting the difficulties with accurate estimation. Positive employment effects have been observed, and official estimates find that 26 600 jobs were created under the ARRA RE and clean energy programmes (Council of Economic Advisors, 2016[19]). There is some evidence that these jobs were of higher quality than average, with salaries equal to USD 44 000 on average, much higher than the whole economy average equal to USD 38 600 (Mundaca and Richter, 2015[20]). Nevertheless, such figures should be viewed cautiously, as they do not take into account the possible destruction of jobs elsewhere as a result of programme implementation.

Numerous methodological challenges have been identified when conducting ex post assessment of ARRA. The main challenge was to estimate the causation and additionality of the stimulus programmes due to the lack of data, lack of clearly defined policy goals and a straightforward

[11] Pollitt (2011[40]) includes policies implemented in the United Kingdom, which was an EU Member State at the time the study was conducted. The United Kingdom left the European Union as of the 31st of January 2020.

counterfactual, especially for estimating employment effects (Mundaca and Richter, 2015[20]). Some intangible benefits, such as policy learning, are even more difficult to measure.

The impact of Green Stimulus in the European Union[12]

EU Member States had made significant commitments towards green stimulus, at an average of 10% of the total package, ranging up to 33% of the entirety of the fiscal stimulus package. The measures included investments in energy efficiency, investments in transport infrastructure, vehicle scrappage schemes, investment in renewables and funds to support eco-innovation.

A study, using a combination of quantitative, qualitative and modelling frameworks, suggests that the overall economic impact of these packages was relatively small, which was mainly due to the fairly small share of green measures in the overall fiscal stimulus package (Pollitt, 2011[40]). The findings of this paper are summarised below.[13]

Belgium's national recovery plan included the following three green recovery measures: investments towards improving the energy efficiency of households (EUR 140 million), investments for households to purchase green technologies (EUR 20 million) and funding for energy cost reduction (EUR 10 million). The Belgian stimulus package was relatively small in scale, hence both economic and environmental impacts were found to be modest.

In the case of the Czech Republic, green measures totalled to around 33% of the total fiscal stimulus. They comprised a EUR 900 million investment into improving the energy efficiency of residential buildings in the form of subsidies for households. The Green Savings Program was estimated to have led to a 0.4% per annum boost in GDP and the creation of 19 000 jobs (OECD, 2018[65]). Environmental impacts were estimated to be relatively small due to the energy intensity of construction work and rebound effects. Long-term environmental benefits, however, were deemed to outweigh short-term environmental impacts (Pollitt, 2011[40]).

Estonia's green stimulus package was mainly focused on water management issues (EUR 153 million), green investments into energy efficiency improvements of buildings and wind energy installation (EUR 44 million), as well as energy efficiency improvements for households (EUR 51 million). Despite being a small, open economy, economic benefits were estimated as having been a 1% increase in GDP for 2008-09 and a small increase in employment.

France's green policies were spread over investments in: improving the energy efficiency of buildings (EUR 400 million), electricity infrastructure (EUR 600 million), transport infrastructure (EUR 1.3 billion), and solar energy (EUR 300 million), a car scrappage programme (EUR 500 million) and funding towards low-carbon R&D (EUR 400 million). The package was estimated to have had a large economic impact but its long-term environmental impacts are uncertain.

Germany implemented four green stimulus policies, namely investments in improving the energy efficiency of buildings (EUR 3.3 billion), R&D support (EUR 500 million), a car scrappage scheme (EUR 5 billion) and revisions of the motor vehicle tax (EUR 1.8 billion).[14] The transport policies boosted GDP by 0.6% in 2009, while environmental benefits manifested themselves in reduced energy consumption and lower emissions. Germany's scrappage scheme also had a

[12] All the quantitative results cited in this subsection draw upon (Pollitt, 2011[40]).

[13] Pollitt (2011[40]) considers policies implemented in the United Kingdom, which was an EU Member State at the time the study was written. The United Kingdom left the European Union as of the 31st of January 2020.

[14] This revision implied a short-run reduction of the tax that was planned to become more stringent over time from 120 g CO_2/km in 2009 to 95 g CO_2/km in 2014 (Malina, 2016[73]).

positive impact on other EU Member States. The first wave of the scheme led to an increase in car imports from the Czech Republic, which contributed a 0.4 percentage point to the Czech Republic's GDP growth in 2009 (Maleček and Melcher, 2016[66]).

Portugal's measures were directed at investment in renewables (EUR 145 million), improving the energy efficiency of private buildings (EUR 100 million), smart meter installation (EUR 15 million), and car scrappage schemes (EUR 45 million). These measures resulted in positive, but modest growth of GDP.

Slovakia's four green measures supported energy-efficiency investments (EUR 10 million), incentives for installing renewable-energy equipment by households (EUR 8 million), support for energy efficiency and renewable-energy projects in the residential sector (EUR 93.5 million) and car scrappage schemes (EUR 55.3 million). The economic impact of the measures was deemed to be relatively large and led to modest reduction in energy consumption.

Sweden's policies included the creation of a venture capital company that supports green innovation (EUR 307 million), funding for R&D on advanced batteries (EUR 8.7 million), and energy efficiency support (EUR 182.8 million). Sweden's focus on research meant that much of the benefits of its stimulus would be felt in the long run and would have considerable spillover effects.

Finally, the United Kingdom[15] implemented various energy efficiency programmes (GBP 215 million in total), flood defence measures (GBP 20 million), railway network extensions (GBP 300 million), offshore wind energy development (GBP 525 million) and support for low-carbon vehicles (GBP 250 million). These measures were found to be small in size, which resulted in fairly small economic impacts, estimated at a temporary boost of 0.1% of GDP in 2009.

Pollitt (2011[40]) suggests that larger stimulus packages, where local conditions as well as domestic sectoral composition were taken into account, along with speedy implementation, was the most effective policy formula for both economic, as well as environmental impact.

Another important finding from the above assessment is that co-ordinated green stimulus measures delivered greater economic impact than green measures implemented by individual countries separately. It was estimated that the short-term multiplier effects, the ratio of the boost to GDP to the size of spending on the measures, from green investment ranged from around 0.6 to 1.1 at national level, and up to 1.5 at European level.

The Korean Green New Deal

An ex post assessment of Korean GND found that overall, while the green stimulus programme was successful in creating jobs and boosting economic growth, climate-related objectives were not met within the allotted time frame (Mundaca and Damen, 2015[64]).

Compared with the baseline scenario of recession, higher unemployment in 2009 and export-led recovery in 2010, the Korean economy recorded strong and consistent growth following the announcement of the GND in 2009, with short-term employment boosted by 276 000 jobs in 2009 (OECD, 2010[67]). However, the GND may not have been the only factor contributing to growth, and some have pointed to the Korean Won's depreciation as a contributor towards increased competitiveness and exports.

[15] Pollitt (2011[40]) considers policies implemented in the United Kingdom, which was an EU Member State at the time the study was written. The United Kingdom left the European Union as of the 31st of January 2020.

That indicators of environmental performance, such as the energy intensity of GDP and the CO_2 intensity of energy, were not significantly improved within this timeframe can be attributed to several factors. First, the export-led growth in the semiconductor and electric appliance manufacturing sectors, as well as the expansion of GND-linked infrastructure, may have been particularly energy intensive. Second, electricity markets were characterised by regulated low electricity prices, insufficient competition, and support to coal power generation (OECD, 2017[61]). Similarly, some markets may have been characterised by important time-lags, such as the implementation of a renewable energy portfolio standard, and a national emission trading scheme (ETS), both of which went online at a later stage, in 2011 and 2012, respectively (Mundaca and Damen, 2015[64]).

Mundaca and Damen (2015[64]) also pointed to the difficulties created by limitations associated with causality and attribution, and asymmetric information. Hence it is important not to draw hasty conclusions regarding the overall environmental effectiveness of the GND, as the lack of a counterfactual and the considerable time-lags in the realisation of environmental performance may mask the true effects of the policy.

Areas for future evaluation

A closer look at this overview reveals that there are also some critical aspects of green stimulus programmes that have not formed part of existing evaluations. Particularly relevant for the COVID-19 context is that most evaluation of green stimulus packages in the wake of the GFC that are reviewed in this paper do not look at distributional consequences. This is potentially important when beneficiaries of a green stimulus differ from the other economic agents bearing the costs of the same stimulus. For instance, the German feed-in-tariff for solar panels and wind turbines mostly benefited some homeowners and farmers but resulted in higher electricity prices paid by all energy consumers (Frondel et al., 2010[25]). To achieve a "just transition"[16], future ex ante and ex post assessments will need to examine distributional impacts.

In addition, very few evaluations assess the international consequences of domestic green stimulus. There is, however, other literature that stresses that some green stimulus measures could risk becoming a form of green protectionism, generating higher costs at the global level but also having significant spillover effects (Box 3.5). This further highlights the importance that countries implement co-ordinated responses to economic crisis especially when their markets are significantly integrated.

[16] A just transition, as defined by the ILO, entails a shift to an environmentally sustainable economy which contributes to the goals of decent work for all, social inclusion and the eradication of poverty (ILO, 2015[74]).

Box 3.5. Potential trade implications of specific green stimulus measures

An important additional dimension to consider, as the diverse responses to the unfolding crisis are implemented, are the possible distortionary trade effects of green stimulus measures. Even during the GFC, economists signalled their concerns regarding the potential of green stimuli and policies being, intentionally or unintentionally, disguised green protectionism. Green protectionism has rarely taken a direct form, such as tariffs, in the wake of the GFC, as countries committed to maintaining both their international trade and environmental commitments (Steenblik, 2009[68]).

However, subsidies were widely provided for certain industries, such as manufacturers of solar photovoltaic cells and modules, and solar-power installations. Differing rates of subsidisation cross countries, at a time when supply is inelastic, can divert inputs towards the countries providing the most generous subsidies, increasing prices for consumers elsewhere (Steenblik, 2009[68]). Certain policies may also favour domestic industries and firms directly or indirectly (Evenett and Whalley, 2009[69]). For example, consumer incentives for greener vehicles or scrapping incentives do not discriminate against imported vehicles, yet the green criteria often vary significantly, and are often tailored to match the strengths and weaknesses of their domestic automobile manufacturers (Steenblik, 2009[68]). There is econometric evidence that European domestic car manufacturers benefited from scrapping subsidies at the expense of foreign producers that were not subject to similar schemes in their respective countries (Grigolon, Leheyda and Verboven, 2016[42]).

It may especially be the case, as has been argued previously, that heightened sentiments towards reduced energy security, expectations of job-creation, and the competitive effects of climate policies may be channelled towards protectionism. Green protectionism could not only erode the international trading system, at a time when the free flow of goods and services is ever more important (OECD, 2020[70]), but also lead to the loss of trust among trading partners.

Finally, by stimulating demand, domestic green recovery packages can stimulate both domestic and foreign industries. As an example of such a spillover, there is some evidence that the first phase of the German scrappage programme generated a significant stimulus for Czech car manufacturing companies (Maleček and Melcher, 2016[66]).

4. Lessons from greening the GFC stimulus

Recent calls for greening the response measures put in place by governments to the COVID-19 crisis bear a striking resemblance to the measures that were called for and, in many cases, implemented as part of the economic stimulus and recovery packages after the GFC. These include investments in energy efficiency, green infrastructure, support for environment-related R&D, and support for vehicle scrappage programmes, which have all been reviewed in the previous section.

Building upon the evaluation presented in this paper, the following key lessons from the GFC that are relevant for greening a COVID-19 recovery stand out:

- *Policy evaluation should be an integral part of green stimulus programmes*

  Despite financial outlays of over half a trillion USD, and over a decade after the GFC, there is a remarkable dearth of assessments of the macroeconomic, labour market and environmental effects of green stimulus packages. Governments should therefore define clear policy objectives and build in ex ante and, in particular, ex post assessment mechanisms into green stimulus measures for COVID-19. This would enable their effects to be evaluated and monitored over time. Considering the heterogeneity in evaluation techniques and practices across countries, there may also be value to sharing best practices and working towards common methodological frameworks.

- *Green measures can deliver on near term economic stimulus priorities*

  Implementation of sufficiently large, timely and properly designed green stimulus measures, which are well-embedded into domestic settings and leverage the strengths of their respective economies, can generate economic growth and bring about environmental benefits. The Korean Green New Deal of 2009 is a prime example of a significant, large green stimulus that led to strong economic growth within a year of its implementation. In the United States, the American Recovery and Reinvestment Act created quality jobs and mobilised significant financing towards renewable-energy deployment, which contributed to a reduction of CO_2 emissions. In the European Union, green stimulus measures contributed positively to GDP growth, and co-ordinated green stimulus measures delivered greater economic impact than green measures implemented by individual countries separately.

- *Whole-of-government co-ordination can help identify and mitigate potential divergence in the achievement of different policy objectives*

  Greening the fiscal stimulus implies the targeting of multiple economic and environmental policy objectives. Performance might vary across these dimensions and over different time horizons (short versus long-term). There may also be trade-offs. For example, in many cases investments aiming to improve energy efficiency were successful at maintaining economic activity in the construction and in the automobile sector but they suffered from rebound effects and delivered little net environmental gain. Conversely, the support to renewable energy generation was successful at reducing the cost of renewable-energy technologies but had little impact on economic growth. These trade-offs call for whole-of-government co-ordination and establishment of clear criteria to identify and mitigate potential divergence in the achievement of different policy objectives within recovery packages.

- *Proper design of green stimulus measures is critical*

  Stimulus packages such as scrappage payments removed inefficient vehicles from the road but in some cases encouraged the purchase of cars emitting more nitrous oxide and bigger cars. They also delivered limited additionality as in many instances they only helped advance new car purchases that would have happened anyway. A more general lesson from the ex post evaluation of green stimulus measures during the GFC is that proper policy design is critical to prevent rebound effects, limit market distortion, and ensure additionality of public funding by improving targeting.

- *Flanking policy instruments that fix underlying environmental externalities are key to delivering greater environmental benefits from the green stimulus*

  This finding points to the fact that when green stimulus investments are assessed against the dynamic backdrop of various market failures such as unpriced environmental externalities, the environmental benefits could be offset or even nullified. To avoid this outcome, environmental externalities must be taken into account and clear signals must be sent to better align incentives.

5. Towards greening a COVID-19 recovery

While the lessons from the GFC discussed in the preceding section remain relevant, the specific proposals to green the COVID-19 response cannot simply be a "cut and paste" from the GFC playbook. This is because there are a number of fundamental differences between the current crisis, which is truly global in its extent, and its predecessors – most notably the GFC – which were financial and economic crises that hit some regions of the world more than others. The current crisis has been accompanied by a significant loss of human life, which continues to climb; a tremendous strain on public health and social infrastructure; and the significantly higher economic and social consequences that continue to unfold.

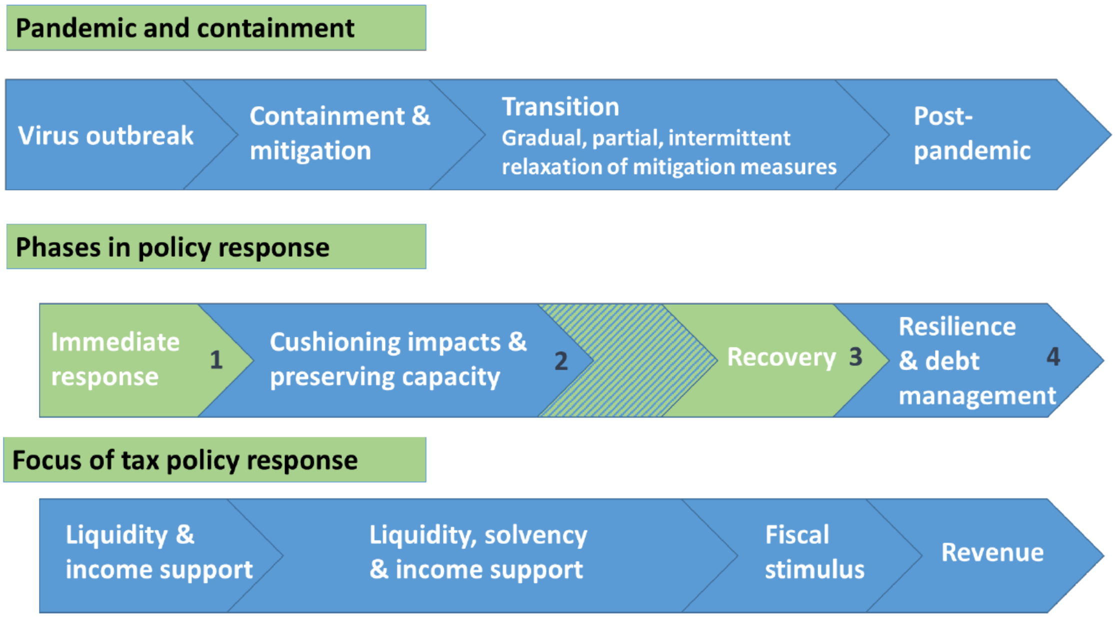
Further, while a key element of past crisis responses was to give an adrenalin shot in the hope of immediately jumpstarting economic activity, the fundamental public health priority to prevent this crisis from worsening is to restrict many economic activities that could escalate virus transmission. There is also significant uncertainty over how long the period of confinement will last, which in turn depends upon progress towards COVID-19 treatment options, and eventually the development of a vaccine. The end of confinement and resumption of economic activity will also be uneven across sectors and countries.

This new context and the unique characteristics of the COVID-19 crisis described above underscore the need to take these special factors into account when planning both the timing and the scope of the response. Figure 2 provides a schematic to conceptualise the phases of the COVID-19 crisis and the (tax) policy response (OECD, 2020[1]). It provides also a useful template to identify opportunities for greening policy responses.

At the time of writing, a majority of countries still find themselves in Phases 1 (immediate response) or 2 (cushioning impacts and preserving capacity) of the crisis response. While clearly the public health, social and economic concerns during these phases are paramount to guiding the policy response, there are some environmental elements that merit attention.

First, while green measures only become relevant as part of stimulus measures in Phase 3 (recovery), and public health and social considerations will rightly dominate Phases 1 and 2, one environmental priority during these two phases could be to *do no harm*. Meeting this objective could include: i) vigilance against any rollback of environmental standards; ii) ensuring that any scale-back or suspension of environmental management activities that has resulted from confinement measures is temporary. For example, in the case of recycling, ensuring that any suspension is time-bound, that households are better informed about handling recyclables so as to minimise sanitary risk for collectors, and that recycling activities are included among the priority sectors that are re-opened when containment measures ease. Doing so is not only necessary from an environmental standpoint, but also because the recycling sector is often dominated by small firms that work on thin profit margins and could risk insolvency over the medium term; (iii) ensuring that support measures in Phase 2 do not inadvertantly exacerbate environmental damage (for example certain construction projects).

Figure 2: Phases of policy response during and after the COVID-19 pandemic



Source: OECD **(2020[1])**.

Once the emphasis of the policy response gradually shifts towards economic recovery (Phase 3 in Figure 2), fiscal stimulus may be needed to support investment and consumption (OECD, 2020[1]). As has been noted, the transition from Phase 2 (cushioning the impacts) to Phase 3 (recovery) may not be smooth (OECD, 2020[1]). Nevertheless, it is in this context that the lessons from the evaluation of the green stimulus packages in the wake of the GFC are most relevant.

Even when economies begin to recover, and they may do so on multiple speeds, society and societal priorities could undergo a significant change as a result of the devastating aftermath of COVID-19. These should be reflected in green stimulus measures, as well. The nexus between public health and the environment, for example, could be a much higher public policy priority now compared with previous crises, especially given the emerging evidence of links between COVID-19 vulnerability and environmental stressors like air pollution. Concern about the social and distributional consequences is also likely to be paramount. Much more so than in the wake of the GFC, to recover from the COVID-19 crisis, policy objectives towards a "just transition" and co-benefits of the health-environment nexus should be considered in the design of green stimulus packages.

There could also be longer-term impacts of COVID-19 on societal preferences that could, in turn, potentially lower the public acceptability of certain green measures like mass transit, while increasing demand for others, such as infrastructure for soft mobility. As growth picks up, governments will also have to consider measures to ensure fiscal consolidation (Phase 4 in Figure 2). In this context they should consider whether and how environmental taxes and pricing of externalities can help create both appropriate price signals as well as contribute to the reinvigoration of public finances.

Finally, COVID-19 is unfolding in a policy environment that is significantly different from 2007-08. The costs of key renewable energy technologies such as solar and wind have fallen dramatically since 2010 compared to other energy sources, making large scale financing more affordable and economically attractive. At the same time, green stimulus measures such as public R&D support could now target technologies that complement renewables but might be further from the market, such as energy storage and smart grids. Another development since the GFC is the heightened attention among governments to improving resource efficiency and the transition towards a more circular economy. Shifting away from unsustainable natural resource use would not only reduce environmental impacts and supply risks, it could also create job opportunities, for example in collecting recyclables, preparing and processing secondary materials and repairing goods. Investments to support repairability, reusability, remanufacturing and recycling, largely absent in the green elements of the GFC stimulus, should also be considered as they can help support value creation and economic resilience. These developments offer new impetus and possibilities for greening the COVID-19 recovery.

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