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LESSONS LEARNED ON GREEN STIMULUS: CASE STUDIES FROM THE GLOBAL FINANCIAL CRISIS

JOEL JAEGER, MICHAEL I. WESTPHAL, AND COREY PARK

HIGHLIGHTS

- About one-sixth of the stimulus spending in response to the 2008–09 global financial crisis was allocated to "green" measures, when using a broad definition of the term.
- The experience of economies like the United States, South Korea, China, and the European Union demonstrates that green investments helped economies recover, created jobs, and built up new industries.
- There were disparities in the speed in which countries were able to disburse green stimulus, and in some cases not all the spending that was announced materialized. A lack of transparency in many countries made it difficult to hold governments accountable for their green spending.
- Global CO_2 emissions fell during the economic contraction but rebounded strongly after the recovery. While few conclusions can be drawn about the emissions impact of green stimulus measures, it is clear there were not enough accompanying reforms to incentivize a low-carbon transition.
- The lessons from the global financial crisis can be applied to the COVID-19 economy recovery. Countries around the world have a chance to design economic recovery packages that quickly create jobs and improve the economy, while also providing climate cobenefits.

CONTENTS

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EXECUTIVE SUMMARY

Introduction

As governments respond to the COVID-19 crisis, they can draw on lessons from the countries that used green stimulus spending to boost their economies and create jobs after the global financial crisis of 2008–09. This paper analyzes the extent to which governments, central banks, and international financial institutions implemented green stimulus in 2008–09 and the effectiveness of these measures. It examines green spending on a global level, then provides case studies from the United States, South Korea, China, and the European Union (EU). The focus is on fiscal measures rather than policy and regulatory changes.

Findings

About US$520 billion was announced for green stimulus measures in 2008–09, 16 percent of the total global fiscal stimulus. Almost 90 percent was spent by the following five economies, in the order of the amount announced: China, the United States, South Korea, Japan, and the EU. Much of this was on heavy infrastructure such as rail transportation, grid modernization, and water/waste management infrastructure (Robins et al. 2010; ILO 2011). These numbers use a broad definition of "green" stimulus, but according to a narrower definition looking only at clean energy such as building efficiency, renewable power, and smart grids, roughly $177 billion was announced (Liebreich et al. 2010). In addition to fiscal policy, many of the world's central banks responded with aggressive monetary policy, including quantitative easing. However, these monetary policies did not target green sectors and have been criticized as maintaining the high-carbon status quo (Matikainen et al. 2017).

Given the available evidence, our four case studies and high-level global assessments conclude that green stimulus spending did help economies recover and did create jobs. The economic and emissions effects of green investments in stimulus packages are difficult to measure, but the few ex post analyses that have been conducted conclude that the green elements of stimulus packages in the United States, South Korea, China, and the EU had a positive effect on gross domestic product (GDP) and employment (see Table ES-1).

Table ES-1 | Key Ex Post Economic Evaluations of Green Stimulus in Response to the Great Recession

UNITED STATES	• The American Recovery and Reinvestment Act (ARRA) supported 900,000 job-years (full-time jobs over one year) in clean energy fields from 2009 to 2015 (Council of Economic Advisors 2016). • Each $1 million of green ARRA investments created 15 new jobs, which arose mostly from 2013 to 2017 (Popp et al. 2020). • The ARRA was successful in stimulating job creation in renewable and energy efficiency sectors (Lim et al. 2020).
SOUTH KOREA	• South Korea's unemployment rate in 2009 was 3.6%, compared to projections of 4.3% if it hadn't been for the stimulus. Short-term public employment increased by a net 165,000 jobs in 2009 (OECD 2010). • South Korea's Green Growth Plan directly created 156,000 new green jobs from 2009 to 2011 (Korean Development Institute, cited in Jung 2015). • The South Korean economy recovered from the economic crisis faster than expected, with green stimulus measures a key contributor (Mundaca and Damen 2015).
CHINA	• The rapid investment in rail and grid networks and other green initiatives in China led to a large and immediate boost to GDP, around 4.2% above the baseline in 2009 and 3.6% above the baseline in 2010 (Pollitt 2011).
EU	• The green elements of the stimulus packages had a small positive impact on European countries' economies in the short run. Each $1 in green investment boosted GDP by $0.60 to $1.10 at the national level and up to $1.50 at the European level. Most green investment policies also led to higher employment levels (Pollitt 2011).

Notes: EU = European Union; GDP = Gross domestic product.

Source: WRI.

In many cases green stimulus was as effective or more effective at creating jobs than spending on fossil fuels or traditional stimulus. U.S. stimulus spending on public transit led to 70 percent more jobs than equivalent spending on highways (Smart Growth America 2011). U.S stimulus spending on coastal habitat restoration created far more jobs than investing in fossil fuels would have (Edwards et al. 2013). In South Korea, non-stimulus investments in renewable energy projects were estimated to create more jobs per dollar than its stimulus spending on dams (Chang et al. 2012). The economic literature corroborates this evidence. According to the International Energy Agency (IEA) (2020), investing $1 million in building efficiency, clean urban transport, or solar photovoltaics (PV) would create more than twice as many gross jobs as investing $1 million in coal or gas power. Restoration and sustainable forest management, electric vehicle charging infrastructure, biofuels, walking and cycling infrastructure, and recycling have also been identified to have high employment multipliers (IEA 2020; Edwards et al. 2013; Blythe et al. 2014; Garrett-Peltier 2011).

In the longer run, investment in clean energy manufacturing and research after the global financial crisis helped countries build up new industries. The United States, China, and Germany became renewable energy leaders in part because of programs coming out of the Great Recession (Varro et al. 2020). In the United States, the share of wind turbine equipment manufactured domestically rose from 25 percent in 2006–07 to 72 percent in 2012 (Mundaca and Richter 2015). China's solar PV manufacturing capacity increased by a factor of 20 between 2007 and 2011 (Earth Policy Institute 2015).

Some green interventions were more popular than others. Ten countries allocated stimulus spending to building efficiency, seeing retrofits as low-hanging fruit to quickly stimulate the economy. Evaluations from the United Kingdom and the United States find that building retrofits created jobs and saved households money on energy bills (Oak Ridge National Laboratory 2015a, 2015b; Nottingham Trent University 2013). At least eight countries implemented car-scrapping schemes, but they only had a modest effect on consumer demand and did not reduce emissions as much as was hoped. Nature-based solutions such as restoration and sustainable agriculture were largely untapped, but the few projects that were undertaken were promising.

There were disparities in the speed with which countries were able to disburse green stimulus, and in some cases not all the spending that was announced materialized. For example, the United States spent 89 percent of the green stimulus that it initially allocated, while Australia only spent 34 percent (Tienhaara 2018). For many countries, a lack of transparency makes it challenging to hold governments accountable for their green spending. In the United States and Europe, more complex projects like high-speed rail and carbon capture and storage proceeded slowly or failed. China and South Korea were able to quickly begin construction of infrastructure projects, but in some cases that was because these were projects that had been planned already, or because the governments relaxed environmental regulations. Some of the projects were not as green as they appeared, including China's funding for rail and grid infrastructure that supported coal use, or a river restoration project in South Korea that built new dams and had a questionable environmental impact.

The international financial institutions and national development banks increased their lending significantly during the 2008–09 economic crisis, including some for renewable energy. The European Investment Bank in particular made climate change central to its finance strategy in that time period. Still, there is no comprehensive assessment from these institutions of the proportion of the overall finance that was green versus polluting.

Global emissions fell during the economic contraction but rebounded strongly after the recovery. This could be because green investments may take time to have an impact on emissions, because of the relatively small size of green spending compared to total stimulus packages, or because of the lack of broader

structural reforms to other parts of the economy that were incentivizing emissions. For example, the world spent 15 times more on fossil fuel subsidies from 2009 to 2013 than it did on the clean energy stimulus that was disbursed in that time period (Liebreich et al. 2010; IEA 2016, 2019). Early projections when the stimulus packages were being implemented estimated that green stimulus in the United States, China, and Europe would decrease emissions and energy use compared to the baseline in the long term (US EIA 2009; WWF 2010; Pollitt 2011); however, there have been no ex post counterfactual analyses, so it is impossible to form firm conclusions about the emissions impact of the green stimulus measures.

Key Recommendations

Drawing on the lessons from the global financial crisis, the following are recommendations for governments to implement green stimulus as part of the COVID-19 recovery:

- Governments should prioritize green investments that have strong economic and social benefits and have the potential to reduce emissions, rather than prioritize fossil fuel investments.
- Governments should clearly define what projects they consider to be green as well as be transparent on disbursement of finance.
- Governments should focus on projects that can scale up quickly to create short-term GDP and employment gains while avoiding untested technologies and more complicated infrastructure projects. Where possible they should focus on scaling up existing projects rather than designing new ones.
- Stimulus alone cannot set the world on a trajectory for a net-zero emissions economy, so it should be accompanied by other policies and fiscal and regulatory reforms, such as phasing out fossil fuel subsidies and use, introducing carbon pricing, and setting emissions targets and standards.
- Governments should undertake more monitoring and evaluation and plan for ex post assessments to understand the economic and environmental impacts of different stimulus measures.

INTRODUCTION

The COVID-19 pandemic is a tragedy that has killed around one million people so far, disrupted lives and livelihoods everywhere, and caused a massive economic slowdown that has impacted the most vulnerable. The immediate response from governments has been focused on stopping the spread of the virus and supporting those who have been affected, as it should be. While it is still unclear how long the emergency relief will need to last, several countries are now turning to more traditional stimulus packages to recover their economies. A few economies such as the European Union (EU)'s have already announced packages that make green measures central to the effort, but for many, sustainability has been an afterthought (Vivid Economics 2020). Countries around the world have a chance to build back better than before by designing stimulus packages that quickly create jobs and increase demand, while also providing climate cobenefits.

Today's policymakers can draw lessons from the response to the global financial crisis. During that crisis, several countries successfully used stimulus spending on green infrastructure to boost their economies and create jobs. While no one country implemented green stimulus measures perfectly, we can learn from previous endeavors what worked and what did not.

This working paper provides a global overview of the extent to which governments and international financial institutions (IFIs) implemented green stimulus measures in response to the global financial crisis and what economic and emissions impact they had. It then provides case studies on the United States, South Korea, China, and the EU. For each economy, a review of the economic literature and analysis of economic and emissions data are used to determine the following to the extent possible:

- How much was spent on green measures
- How much was spent on polluting measures
- How successfully the stimulus was implemented
- What was the impact on economic outcomes and particularly on jobs
- What was the impact on emissions and other environmental outcomes.

The paper then briefly examines the differences between the global financial crisis and today's crisis and presents recommendations.

The bulk of this paper focuses on fiscal stimulus policies by national governments, particularly investments in infrastructure. More research is needed on how regulatory changes, bailouts to businesses, and other policies impacted the environment in the context of the Great Recession. Several other recent papers have evaluated the lessons from green stimulus measures in 2008–09, including Agrawala et al. (2020), Varro et al. (2020), and Barbier (2020), which address these questions to some extent.

DEFINING GREEN STIMULUS

There are various understandings of what counts as "green." The most common terms include "clean energy" stimulus, "green" stimulus, and "low-carbon" stimulus. "Clean energy" stimulus normally includes investments in renewable energy and energy efficiency, but sometimes includes other investments that impact energy use like rail transportation and electric vehicles. "Green" stimulus often encompasses these categories and expands to include nature-based interventions such as protecting and restoring forests and other environmentally beneficial activities that reduce air pollution, improve water quality and supply, or promote climate mitigation, adaptation, or resilience. "Low-carbon" stimulus typically focuses entirely on the emissions impact of an intervention. This becomes complicated because different countries may be on different decarbonization pathways—for example, power transmission line investments could be helpful if they connect renewables to the grid or harmful if they connect fossil fuels (Westphal and Masullo 2018).

Within these broad categories, many sources use different definitions for each of these terms. In many cases, governments have their own definitions of whether a project is green or not, which must be viewed critically. Depending on the individual definition, more controversial interventions like large hydropower, natural gas, nuclear energy, and carbon capture and storage may or may not be included. It is beyond the scope of this piece to present a normative definition of green finance, but there are ongoing efforts to do so (Climate Bonds Initiative 2018; European Commission 2020; IDFC 2019).

The most complete and commonly cited sources for global green stimulus data are Robins et al. (2009), Robins et al. (2010), and Liebreich et al. (2010). Robins et al. (2009) and Robins et al. (2010) use a broad definition of green stimulus, including all the categories listed in Table 1. Liebreich et al. (2010) adapt the data from Robins et al. (2009) to focus more narrowly on clean energy stimulus. Our paper uses the broad "green" stimulus definition unless otherwise noted. To provide more specificity, whenever possible, we discuss the specific sectors that received stimulus rather than the amount that went to green stimulus overall.

GLOBAL OVERVIEW

Green Stimulus Spending

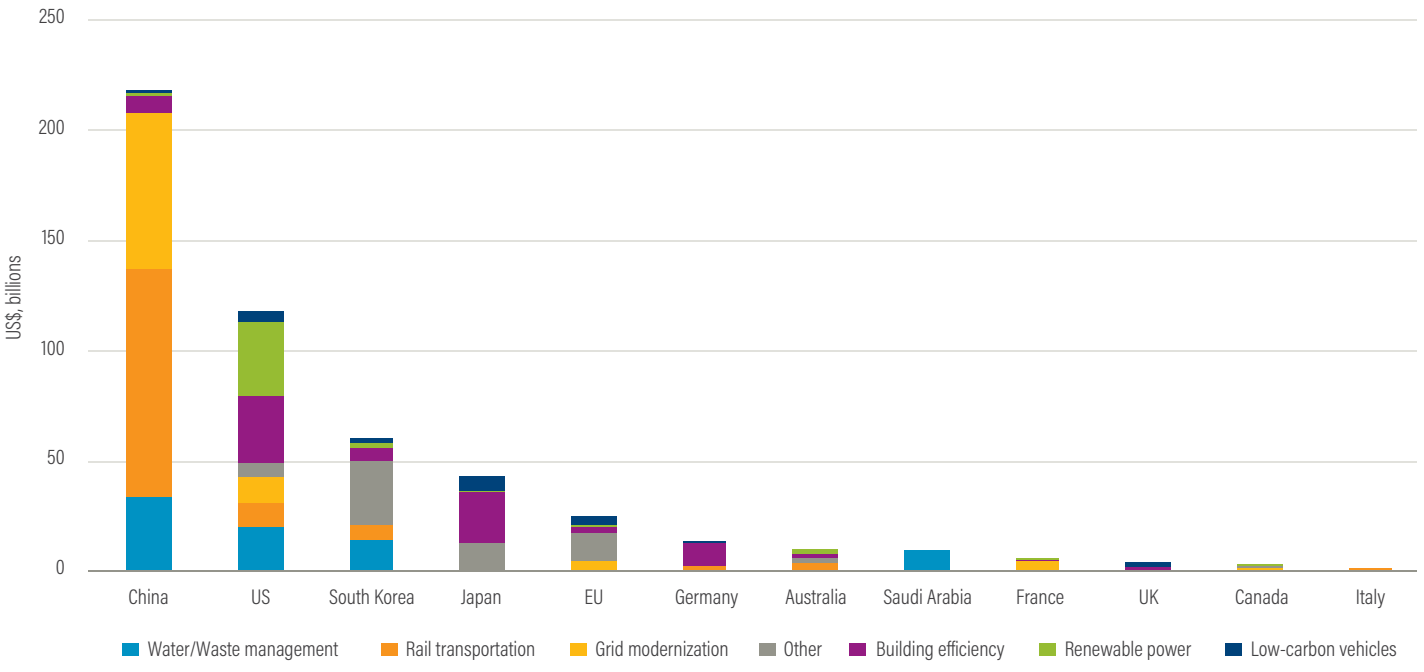
Globally, about US$520 billion out of the $3.25 trillion fiscal stimulus went to green measures, when using a broad definition of the term (Robins et al. 2009; Robins et al. 2010; ILO 2011). Almost all of the global green stimulus was spent by the Group of 20 (G20), which comprises 19 countries and the EU. China allocated $218 billion, about a third of its stimulus package, to green measures. Almost all of this was spent on rail transportation, grid, and water management. The United States announced $118 billion in green stimulus, about 12 percent of its total. This included $33 billion on renewable power, three times more than the rest of the world combined. South Korea announced 69 percent of its stimulus for green measures, the highest share of any country, though it did not provide much detail on the breakdown. Japan and the EU round out the top five. Globally, the biggest category of green spending was on rail transportation (26 percent of the total), followed by grid modernization (18 percent), building energy efficiency (17 percent), water/waste management (15 percent), renewable power (8 percent), and low-carbon vehicles (4 percent). These data are presented in Figure 1 in total terms and in Figure 2 as a share of each country's gross domestic product (GDP).

Table 1 | **Two Commonly Used Sources on Green or Clean Energy Stimulus**

	ROBINS ET AL. (2010) *NOT PUBLICLY AVAILABLE BUT CITED IN ILO (2011)*	LIEBREICH ET AL. (2010)
TERMINOLOGY	**"GREEN" STIMULUS**	**"CLEAN ENERGY" STIMULUS**
Investment categories included	• Renewable energy • Building efficiency • Efficient and low-carbon vehicles, including electric vehicles • Grid modernization • Rail transportation • Water management, including sewage treatment, dams and flood defenses, canals and waterways, and environmental restoration • Carbon capture and storage • Nuclear energy	• Renewable energy • Building efficiency • Efficient and low-carbon vehicles, including electric vehicles • Smart grid • Other
Time frame and scope	• Announced stimulus packages from September 2008 to December 2009 and announced stimulus spending as part of fiscal year 2009–10 budgets	• Announced stimulus packages from September 2008 to February 2009
How much was allocated globally after the global financial crisis?	$521 billion in green stimulus	$177 billion in clean energy stimulus

Source: WRI.

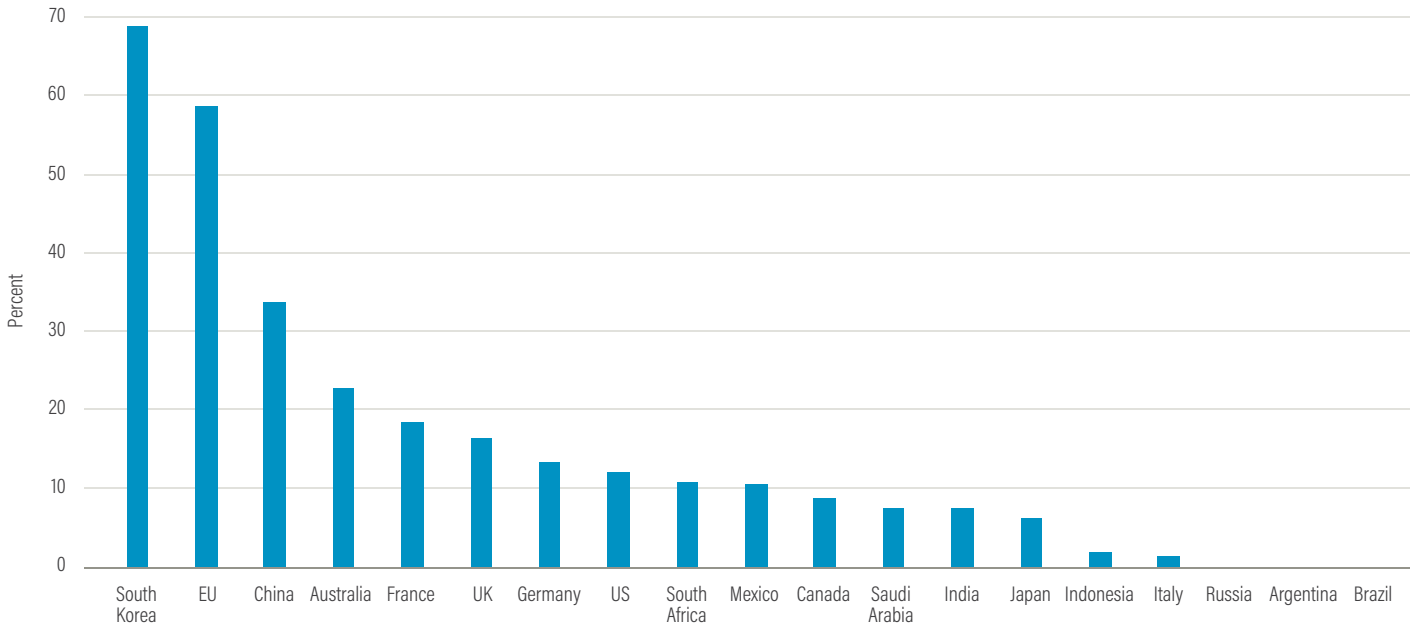
Figure 1 | **Announced Green Stimulus by Country (September 2008–December 2009)**



Notes: Water/Waste management includes sewage treatment, dams and flood defenses, canals and waterways, and environmental restoration. Rail transportation includes railways and public transit. Vehicle efficiency includes low-carbon vehicles, vehicle efficiency, and electric vehicles. Other includes projects defined by governments as green, but without details, plus carbon capture and storage and nuclear power. In most cases these estimates rely on government definitions of categories. These estimates are based on stimulus as announced, not as implemented.

Sources: Robins et al. 2009; Robins et al. 2010; ILO 2011.

Figure 2 | **Announced Green Stimulus as Percentage of Total Stimulus (September 2008–December 2009)**



Notes: Data from Robins et al. (2010)—cited in ILO (2011) and others—put the percentage of South Korean green stimulus to total stimulus at around 80 percent, but those data do not include a $10.9 billion non-green stimulus that South Korea announced in November 2008 (Wassener 2008; Tienhaara 2018).

Sources: Robins et al. 2009; Robins et al. 2010; ILO 2011; Barbier 2011; Tienhaara 2018.

Looking only at clean energy stimulus (including renewable energy, efficiency, smart grid, and low-carbon vehicles), $177 billion was announced by the 13 largest spenders in 2008 and 2009. The United States was the top spender, with $67 billion; China was second with $47 billion; and South Korea was third with $16 billion (Liebreich et al. 2010).

These estimates must be treated cautiously because they are based on the green stimulus measures as announced, not as disbursed. For some countries that have closely tracked their green stimulus spending, it is possible to see how much was disbursed: for example, in the United States 89 percent of the funds that were initially allocated for green stimulus were spent, in Canada 77 percent of the initial allocation was spent, while in Australia only 34 percent was spent (Tienhaara 2018). In some countries the disbursement process was opaque or the amount of money that was announced for green measures was later reduced (Horn-Phathonothai 2009; Liebreich et al. 2010; Tienhaara 2018).

Economic Impact

The goal of a stimulus is to help the economy recover, including stimulating demand, raising output, creating jobs, and advancing new industries. The most effective fiscal stimulus has impact on the ground as fast as possible and has a high economic return for every dollar spent in both the short and long term (Hepburn et al. 2020). Some investments are better for stimulating the economy quickly, like unemployment compensation, while others set an economy up for future growth, like investment in new technologies; an ideal stimulus package has elements of both. There are also

choices to be made about what types of financial and policy instruments to use to make green investments. A review of the literature found that direct government investment delivers higher economic multipliers than tax reductions (Mafouz et al. 2002; Hepburn et al. 2020).

The economic effects of green investments in stimulus packages are difficult to measure. Wherever possible this paper uses after-the-fact, ex post evaluations, but our survey of the literature and other recent surveys (Agrawala et al. 2020; Varro et al. 2020) uncover only a few such assessments. There are other complicating factors that make it difficult to understand the economic effects, including the lack of a counterfactual no stimulus scenario for comparison purposes; the difficulty in disentangling the effects of green components compared to the rest of the stimulus; and the fact that many studies only report gross jobs added rather than the net effects. When reporting jobs data, this paper strives to specify net jobs effects rather than gross effects and identify the time span of the jobs created by using units of job-years (full-time jobs over one year) or job-hours.

Given the available evidence from 2008 to 2009, green stimulus spending did help economies recover and did create jobs. Table 2 provides some key ex post evaluations of the economic impacts of green spending in the United States, South Korea, China, and the European Union. In these economies green stimulus spending increased GDP, created jobs, and helped build up new industries, generally with success but sometimes with difficulty or more slowly than expected. Our case studies go more in-depth. In recent months a few high-level assessments have also concluded that green interventions after the global financial crisis provided effective economic stimulus (Hepburn et al. 2020; Agrawala et al. 2020).

Table 2 | **Key Ex Post Economic Evaluations of Green Stimulus in Response to the Great Recession**

UNITED STATES	• The American Recovery and Reinvestment Act (ARRA) supported 900,000 job-years (full-time jobs over one year) in clean energy fields from 2009 to 2015 (Council of Economic Advisors 2016). • Each $1 million of green ARRA investments created 15 new jobs, which arose mostly from 2013 to 2017 (Popp et al. 2020). • The ARRA was successful in stimulating job creation in renewable and energy efficiency sectors (Lim et al. 2020).
SOUTH KOREA	• South Korea's unemployment rate in 2009 was 3.6%, compared to projections of 4.3% if it hadn't been for the stimulus. Short-term public employment increased by a net 165,000 jobs in 2009 (OECD 2010). • South Korea's Green Growth Plan directly created 156,000 new green jobs from 2009 to 2011 (Korean Development Institute, cited in Jung 2015). • The South Korean economy recovered from the economic crisis faster than expected, with green stimulus measures a key contributor (Mundaca and Damen 2015).
CHINA	• The rapid investment in rail and grid networks and other green initiatives in China led to a large and immediate boost to GDP, around 4.2% above the baseline in 2009 and 3.6% above the baseline in 2010 (Pollitt 2011).
EU	• The green elements of the stimulus packages had a small positive impact on European countries' economies in the short run. Each $1 in green investment boosted GDP by $0.60 to $1.10 at the national level and up to $1.50 at the European level. Most green investment policies also led to higher employment levels (Pollitt 2011).

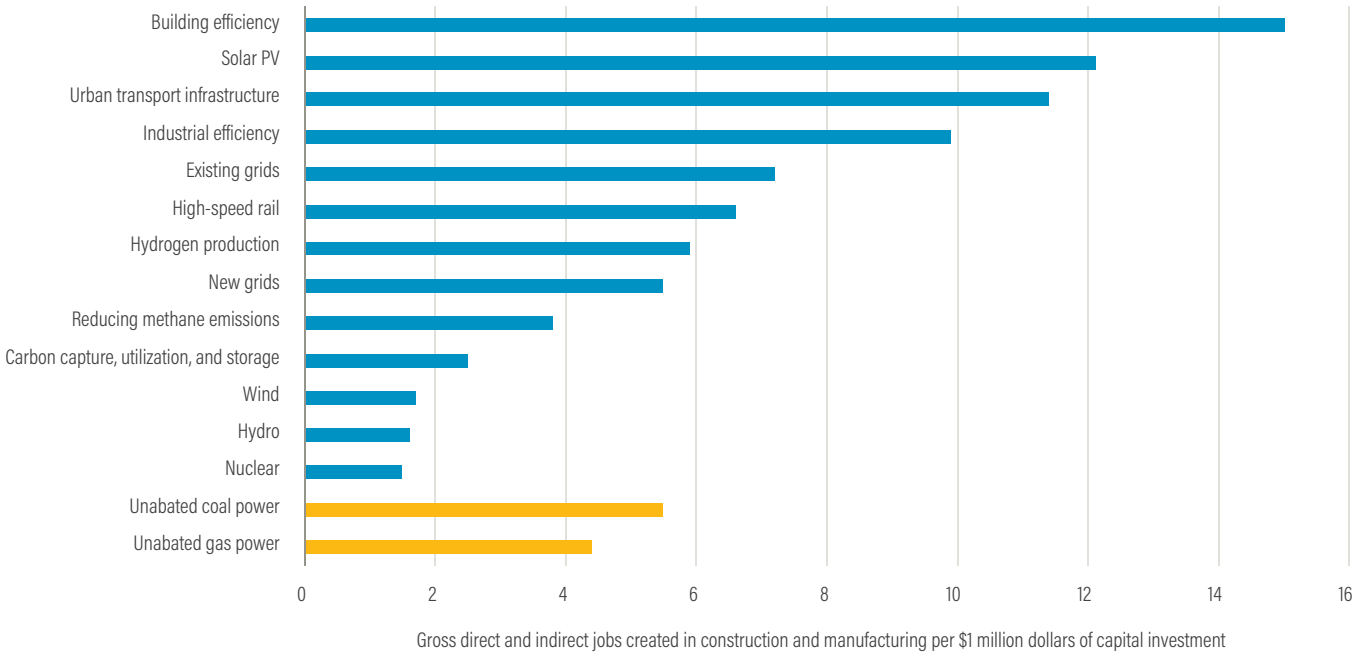
Notes: EU = European Union; GDP = Gross domestic product.

Source: WRI.

Box 1 | Green Investment and Job Creation in the Economic Literature

The economic literature suggests that many types of green investments create more jobs than fossil fuel investments do. According to the International Energy Agency (IEA) (2020), investing $1 million in building efficiency, clean urban transport, or solar photovoltaics (PV) would create more than twice as many gross jobs as investing $1 million in coal or gas power (see Figure B1). Restoration and sustainable forest management, electric vehicle (EV) charging infrastructure, walking and cycling infrastructure, biofuels, and recycling have also been identified as having high employment multipliers (Edwards et al. 2013; IEA 2019; Garrett-Peltier 2011; Blythe et al. 2014). Other studies and systematic reviews arrive at different employment multipliers for individual technologies (e.g., wind investments have a lower multiplier in the IEA report than elsewhere), but overall the takeaway is the same: clean energy often creates more jobs than other infrastructure investments in the short term (Blythe et al. 2014; Garrett-Peltier 2017; IRENA 2020; Edwards et al. 2013). This is because green projects like installing solar panels or planting trees are more labor-intensive than highly automated, capital-intensive fossil fuel projects. They may also require less-skilled labor or be part of the gig economy, which means that wages and benefits would be lower. Employment multipliers vary by region—they are highest in Latin America and Southeast Asia and lowest in Europe, North America, and Oceania (IRENA 2020). More research is needed on employment multipliers in low-income countries.

FIGURE B1 | JOBS CREATED PER $1 MILLION



Notes: PV = Photovoltaics; IEA = International Energy Agency.

Source: IEA 2020.

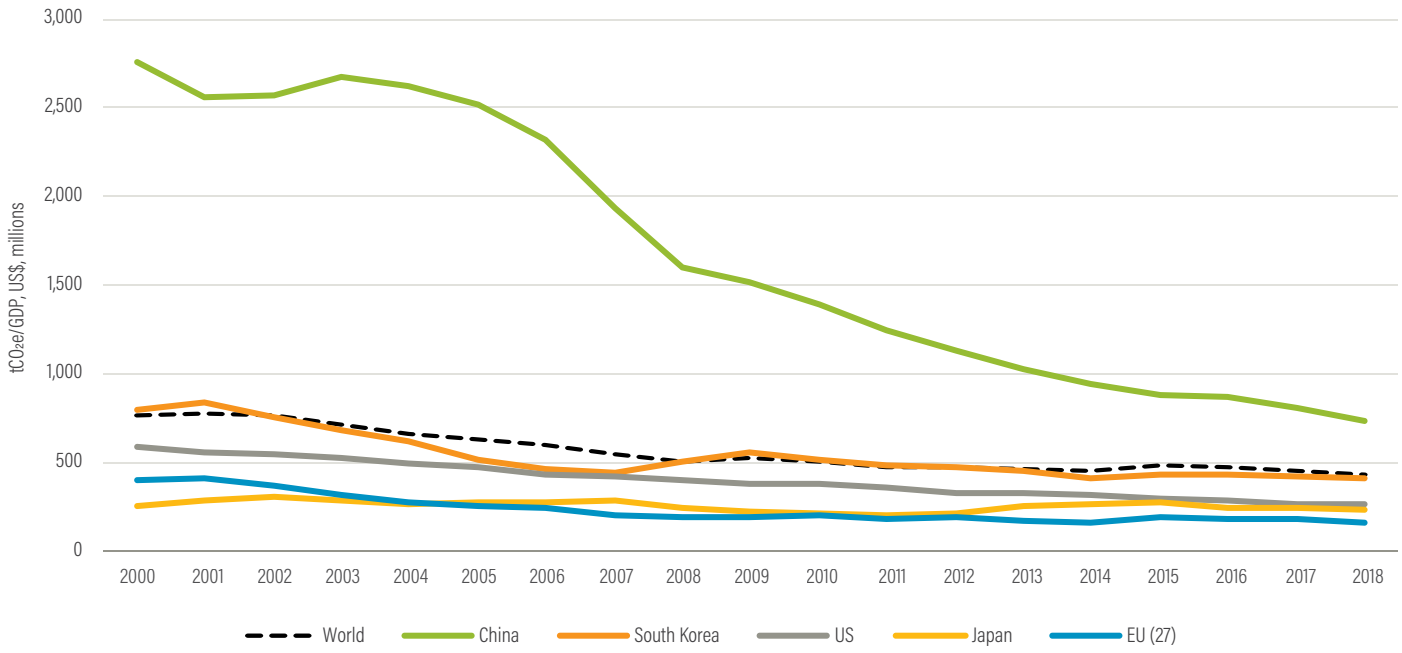
Emissions Impact

Global CO_2 emissions from fossil fuels and cement fell 1.4 percent in 2009 because of the global recession but increased 4.3 percent in 2010, the biggest annual increase in decades, and continued to climb upward for years (Global Carbon Project 2020). Even among the five countries that spent the most on green stimulus, in the years after the recovery the amount of CO_2 emissions per unit of GDP did not improve or remained on about the same trajectory as before (Figure 3). Some early projections when the stimulus packages were being announced estimated that they would decrease emissions compared to the baseline (US EIA 2009; WWF 2010; Pollitt 2011); however, it is impossible to form conclusions about green stimulus overall because there have been no ex post counterfactual analyses. Nonetheless, we do have research that calculates the emissions impact of some individual stimulus interventions, as presented in the case studies.

There are several possible explanations for the bounce back in CO_2 emissions. First, green investments may take time to have an impact on emissions. For example, stimulus efforts to support clean energy manufacturing and research will not immediately reduce emissions, but can be foundational in building up the supply chains and infrastructure to make clean energy widespread in the long term.

Second, the green stimulus measures were relatively small compared to the rest of the fiscal stimulus; in some cases the green investments were directly counterbalanced by additional investments in high-emitting sectors (Robins et al. 2010; ILO 2011). At least eight countries provided support to the automobile industry, and heavy infrastructure projects like railways and grid expansion led to higher production of iron, steel, and cement (Schweinfurth 2009; WWF 2010).

Figure 3 | Carbon Intensity of GDP before and after the Global Financial Crisis (2000–2018)



Notes: tCO_2e = Tons carbon dioxide equivalent; GDP = Gross domestic product.

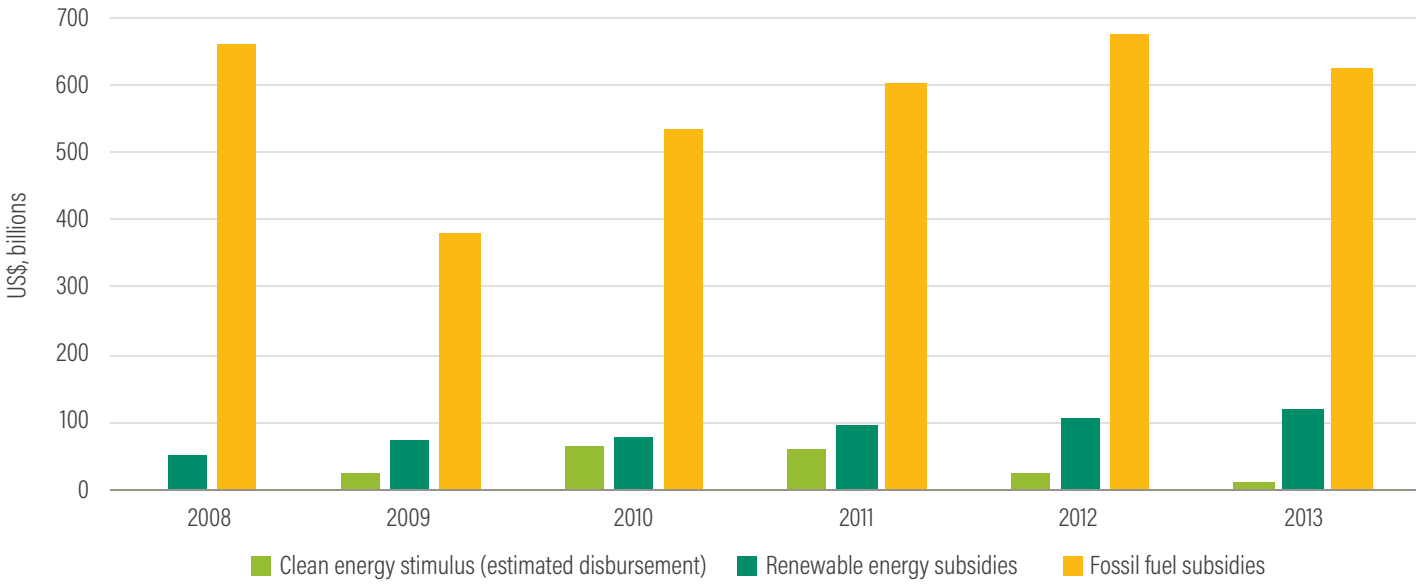
Source: Global Carbon Project 2020.

Third, the green stimulus measures were not accompanied by broader structural reforms that could have incentivized a low-carbon transition (Agrawala et al. 2020). For example, while fossil fuel subsidies fell during the recession, they rebounded strongly in 2010 and 2011, despite a G20 pledge to phase them out (IEA 2016, 2019; OECD 2018b). Fossil fuel subsidies totaling $2.8 trillion were spent from 2009 to 2013, 15 times higher than the $177 billion in clean energy stimulus spending disbursed in the same time frame and also higher than the amount spent on renewable subsidies outside of the stimulus (see Figure 4). These numbers pertain only to the energy sector; there are still other distortions such as agricultural subsidies that incentivize polluting activities like excessive use of fertilizer (Searchinger 2020). Moreover, less than 5 percent of the world's GHG emissions were covered by some sort of carbon price during the financial crisis (World Bank 2020).

The Role of Central Banks

Many of the world's central banks responded to the Great Recession with aggressive monetary policy, including quantitative easing (QE), the large-scale purchase of assets such as sovereign or supranational bonds, asset-backed securities, covered bonds, corporate bonds, or equities (Williamson 2017). In the United States, the Federal Reserve (the Fed) implemented three phases of QE starting in 2008: Purchases of $175 billion in agency securities and $1.25 trillion in mortgage-backed securities (QE1); purchases of $600 billion in long-maturity Treasury securities; and purchases of at least $40 billion per month for mortgage-backed securities and $45 billion per month for long-maturity Treasury securities (Williamson 2017). The Bank of England started QE in 2009, and by 2012, QE totaled $603 billion.[1] Likewise, the European Central Bank (ECB)'s QE program included

Figure 4 | **Fossil Fuel Subsidies Outweighed Clean Energy Stimulus**



Notes: Green stimulus disbursement includes the 12 major economies that announced $1 billion or more in green stimulus. Renewable subsidies are global. Fossil fuel subsidies include consumption subsidies from 41 developing economies and production and consumption subsidies from Organisation for Economic Co-operation and Development (OECD) countries.

Sources: Liebreich et al. 2010; IEA 2016, 2019; OECD 2018b; Authors.

the purchase of government bonds totaling $306 billion and two rounds of loans totaling $1.39 trillion (Anderson 2015).[2] The Bank of Japan, which was the first to use QE, began a modest program in 2010 to purchase $60 billion in assets, but after 2013 significantly scaled up QE ("Abenomics") (Agostini et al. 2016).

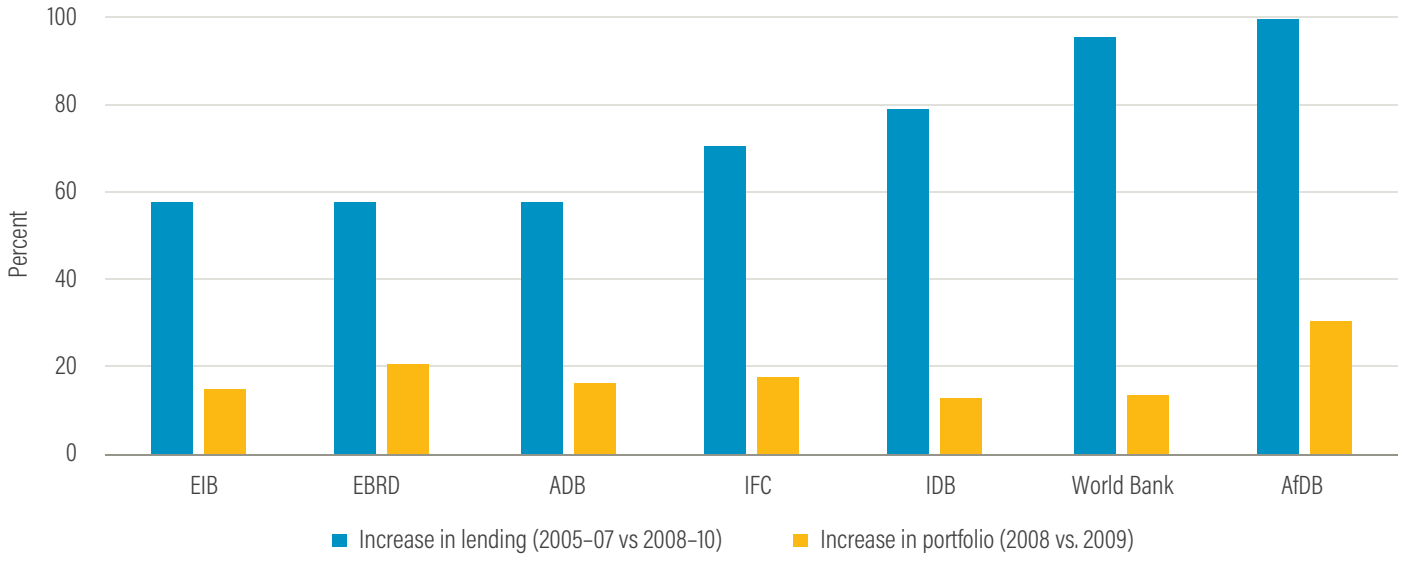
However, these QE programs did not target green sectors. The Fed deliberately targeted mortgage-backed securities in its first round of QE to "provide support to mortgage and housing markets." The ECB and the Bank of England aimed for "neutrality" in the sense of avoiding market distortions, and allocated purchases according to the makeup of the market. This has been criticized as maintaining the high-carbon status quo (Matikainen et al. 2017). Indeed, an analysis of the ECB's and Bank of England's corporate bond purchase program this decade indicates a skew toward carbon-intensive areas such as manufacturing and electricity and gas production, disproportionate to their contribution to the economy (Matikainen et al. 2017).

The Response of Development Finance Institutions

International finance institutions increased their portfolios by $101 billion in 2009 (Figure 5). The multilateral development banks (MDBs) all responded similarly, ramping up crisis lending and addressing secondary crisis effects, such as credit contraction and the drying up of trade finance, largely relying on preexisting instruments (Independent Evaluation Group 2012) Among MDBs the World Bank and African Development Bank (AfDB) increased lending by the largest amounts (Independent Evaluation Group 2012). The International Monetary Fund (IMF) increased its lending by a staggering 2,131 percent between 2005–07 and 2008–10 ($166 billion in 2010) (Independent Evaluation Group 2012).

Some development finance institution (DFI) green finance did increase markedly in response to the economic crisis, most notably for renewables. Overall development assistance for

Figure 5 | Multilateral Development Bank Lending during the Economic Crisis



Notes: Lending includes new commitments across all financial instruments in that year, while portfolio refers to all gross outstanding loans, equity investments, guarantees. EIB = European Investment Bank; EBRD = European Bank for Reconstruction and Development; ADB = Asian Development Bank; IFC = International Finance Corporation; IDB = Inter-American Development Bank; AfDB = African Development Bank.

Source: Independent Evaluation Group 2012.

renewables in developing countries went up from $2 billion in 2008 to more than $5 billion in 2009. World Bank Group finance for renewables increased fivefold in 2009 to $1.38 billion. The Inter-American Development Bank (IDB) committed more than $1 billion in loans for renewable energy, while the Asian Development Bank (ADB) invested approximately $93 million in renewables (including large hydropower). Among the national development banks, Germany's KfW Banking Group increased its lending to renewable energy from €5.4 billion ($7.9 billion) in 2008 to €6.3 billion ($8.8 billion) in 2009,[3] while renewables investment by the Brazilian National Bank of Economic and Social Development (BNDES) went from $2.4 billion in 2007 to $7.0 billion in 2008 and $6.4 billion in 2009 (REN21 2010). Moreover, the China Development Bank reported that its "environmental protection" lending (e.g., urban and river basin environmental protection, industrial pollution control and recycling, clean energy, and ecological projects) doubled to $33.8 billion between 2009 and 2010 (Matisoff 2012).[4]

While overall green DFI finance did increase and some DFIs scaled up renewable energy finance, there is no comprehensive assessment of the proportion of the overall finance that was green versus polluting. Official development assistance from multilateral institutions[5] for agriculture increased slightly between 2007 and 2010 (4.9 percent to 5.8 percent of total), while for energy it decreased marginally (7.1 percent to 6.2 percent), but Organisation for Economic Co-operation and Development (OECD) Development Assistance Committee data from that period are not disaggregated further into green categories (OECD DAC 2020). Likewise, there are no comprehensive data on whether there was an overall increase in the green lending at national development banks.

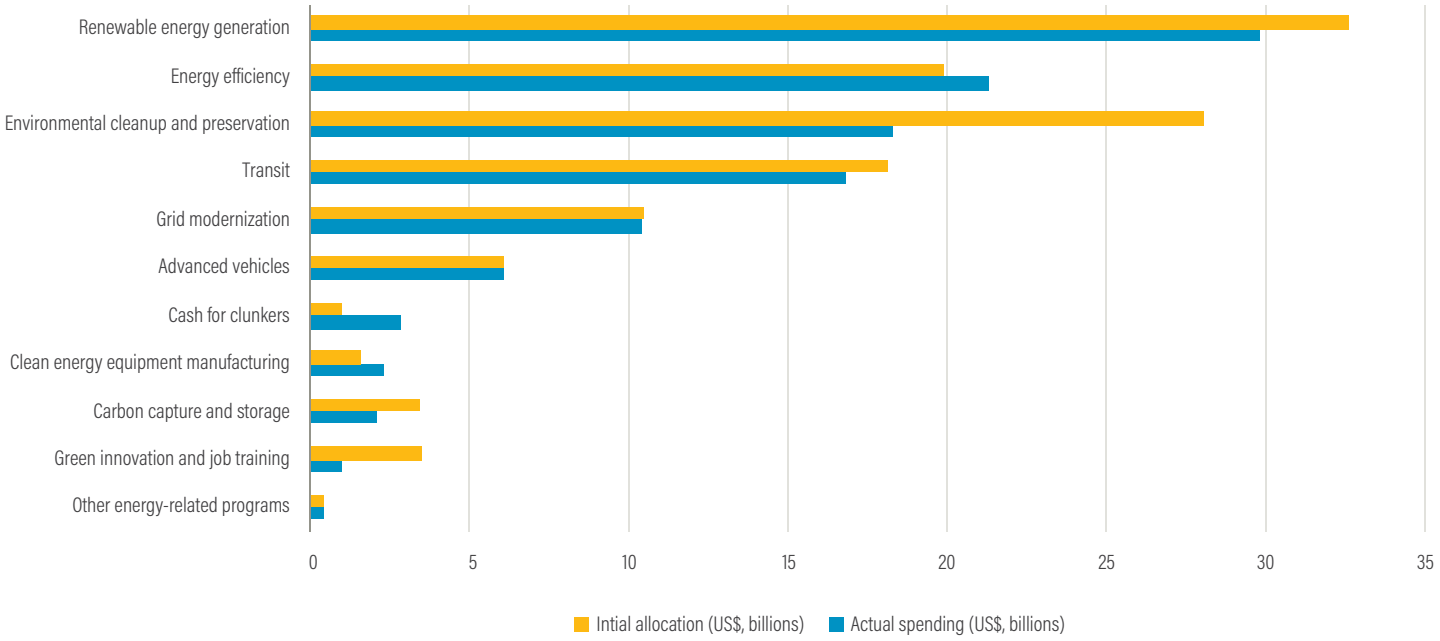
At the MDBs, at least, green finance overall did not grow disproportionately during the crisis, except at the European Investment Bank (EIB). The EIB made climate change one of its three foci in response to the economic crisis. It increased lending to initiatives to act against climate change from $14.4 billion in 2008 to $23.6 billion in 2009, a significant proportion of EIB's $69.5 billion crisis response between 2008 and 2010 (EIB 2010). In contrast, one of the main responses at the ADB during the crisis was the expansion of its Trade Finance Program to $1 billion;[6] in 2010, 95 percent of this finance supported the import of raw materials, and 39 percent supported oil, gas, and energy-related products (ADB, Independent Evaluation Department 2011). The European Bank for Reconstruction and Development (EBRD) reported that the sectoral distribution of projects did not show any major change over 2008 (EBRD, Evaluation Department 2010), and the percentage of lending and guarantees in the environment sector at the IDB did not change significantly between 2008 and 2009 (IDB 2008, 2009). At the AfDB, infrastructure sector approvals increased more than 177 percent between 2008 and 2009 and environment sector approvals declined by 37 percent (AfDB 2009). Likewise, at the World Bank, while all sectors increased their lending, the biggest increases during the crisis period—exceeding 150 percent—were for poverty reduction and economic management, financial and private sector development, and human development.[7] In fact, the percentage of disbursements for the environment sector declined slightly from 2005–07 (13.2 percent) to 2009–10 (12.0 percent) (Independent Evaluation Group 2012).

CASE STUDIES

United States

The 2009 American Recovery and Reinvestment Act (ARRA) was the largest clean energy investment in U.S. history (Council of Economic Advisors 2016). The ARRA allocated about $94 billion to green measures, about 12 percent of the total package (Robins et al. 2010; ILO 2011).[8] It also leveraged approximately $150 billion in private and other nonfederal capital for clean energy investments, according to the government (Council of Economic Advisors 2016). Unlike some other countries, the United States followed through on the vast majority of its promised green stimulus spending. Of the money allocated, 89 percent was eventually spent (see Figure 6) (Tienhaara 2018).

Figure 6 | **US Green Stimulus Spending by Sector**

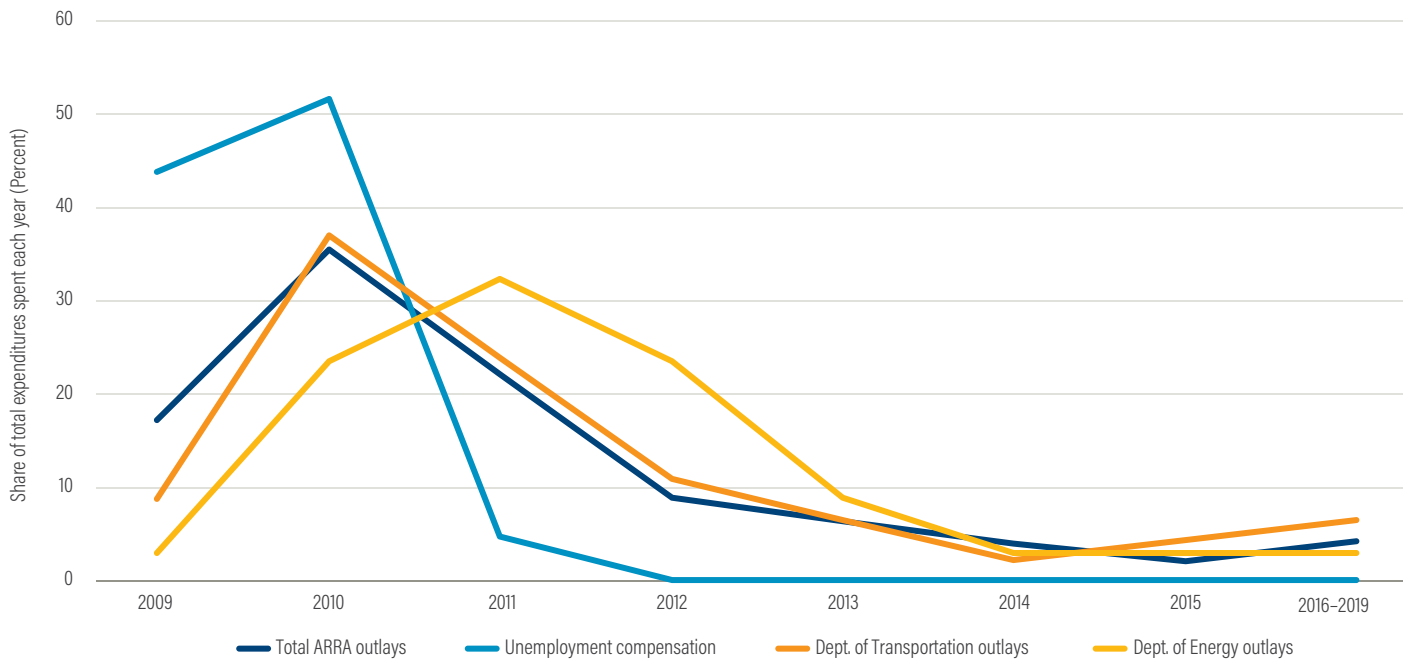


Source: Tienhaara 2018.

ARRA allocations to all sectors were spent over a long time frame, peaking in 2010 but extending out for an entire decade. Some types of spending, like unemployment compensation, were disbursed quickly, while transport and energy infrastructure spending was a bit slower (Figure 7) (Congressional Budget Office 2015). The other concern with stimulus disbursement is that sometimes money went to projects that would have happened even without that funding, according to a survey of firms that received ARRA contracts (Jones and Rothschild 2011).

The green investments in the ARRA created jobs. An after-the-fact assessment by the Obama administration found that the ARRA supported 900,000 job-years (full-time jobs over one year) in clean energy fields from 2009 to 2015, with most of the jobs created in the first few years after the stimulus (Council of Economic Advisors 2016). However, a recent peer-reviewed ex post evaluation concluded that while green ARRA spending increased total employment, it worked more slowly than other stimulus investments, with the jobs arising mostly from 2013 to 2017, so the question of timing is still up for debate (Popp et al. 2020). If job creation was slow, it could be because green programs experienced administrative delays, or more positively because the initial government investment facilitated private investment later. The jobs created were lasting rather than temporary, meaning that green investments led to durable changes in the economy. The study also noted that nearly all the jobs created by ARRA green investments were in manual labor, and most had lower wages than the average manual labor job. It found that green ARRA investments were much more likely to go to communities that already had green skills built up.

Figure 7 | **Speed of Disbursal of American Recovery and Reinvestment Act Funds by Category (2009–2019)**



Source: Congressional Budget Office 2015.

ARRA investments in the renewable energy sector were successful in creating short-term employment and spurred a clean energy revolution in the United States as capacity grew and prices dropped. Ex post studies shown in Table 3 found that renewable energy grants and loans created jobs. The grants program received $25.0 billion in funding, and the loans program originally received $6.0 billion, but Congress later reduced it to $2.5 billion. Still, the loans had a default rate of only 2.3 percent, less than had been built into the budget when the program began, and a comparable rate to similar private sector investments (Tienhaara 2018). Thanks to the ARRA and other investments and policy reforms, U.S. solar electricity generation increased over 30 times from 2008 to 2015, and wind generation has increased over three times (Council of Economic Advisors 2016). The number of wind turbine manufacturing facilities in the United States increased tenfold between 2004 and 2011 to reach 470. The share of wind turbine equipment manufactured domestically rose from 25 percent in 2006–07 to 72 percent in 2012 (Mundaca and Richter 2015).

The United States also made energy efficiency retrofits a priority during its recovery, as the projects could begin immediately. It increased the budgets of the Department of Energy's Weatherization Assistance Program and State Energy Program by an order of magnitude (Council of Economic Advisors 2016; Oak Ridge National Laboratory 2015a). Ex post evaluations of both energy efficiency programs have found that they supported jobs and reduced emissions (see Table 3). The United States had success with its energy efficiency retrofits because it funneled spending through existing

programs and provided comprehensive retrofit options that could be tailored for individual home needs. By contrast, Australia's home retrofits program was not based on an existing program, so was implemented more slowly, and it only provided one technology, insulation, which was not effective for all homes (Tienhaara 2018).

U.S. spending on public transit created more jobs per dollar than spending on highways. The United States spent $8.4 billion specifically on public transit through the ARRA (U.S. Department of Transportation 2017). For some of the other ARRA transportation funding, states could choose where to use it and spent only $0.6 billion on public transit compared to $24.6 billion on roads. When states had the choice, $1 billion spent on public transit projects created 70 percent more job-hours than $1 billion spent on highways (Smart Growth America 2011).

Finally, ARRA spending on coastal habitat restoration was an effective job creator. It created about 17 job-years in the immediate term per $1 million spent, which is higher than for investments in fossil fuels (Edwards et al. 2013). There are also longer-term economic benefits, including increased property values, future job creation from rebounded fisheries and tourism, and resilience to climate impacts. The program had $167 million to disburse but received $3 billion in applications (Edwards et al. 2013). In a related area, $4 billion was spent on the Clean Water State Revolving Fund under the ARRA. Of that, 20 percent was set aside for green infrastructure water projects, but in the end that amount reached 30 percent. These projects included energy efficiency, green stormwater infrastructure, and water efficiency. They created thousands of jobs and saved millions of gallons of water (EPA 2015).

Table 3 | **Sector-Specific Ex Post Evaluations of Green Stimulus in the American Reinvestment and Recovery Act**

SECTOR	EX POST EVALUATIONS
Renewable energy	• $25 billion in cash grants estimated to support 44,000–66,000 short-term jobs in wind energy and 8,300–9,700 short-term jobs in solar PV from 2009 to 2013, and 4,500–4,900 permanent jobs for wind and 610–630 permanent jobs for solar for the 20–30 year operational lifetime of the projects (Steinberg et al. 2012). • $2.5 billion in loans estimated to support 8,000 short-term construction jobs and 500 permanent jobs. Helped fund the first five utility-scale solar PV facilities in the country and one of the largest wind farms in the world (Tienhaara 2018).
Energy efficiency	• In 2010, the Weatherization Assistance Program directly and indirectly supported 28,000 jobs and reduced carbon emissions 7.4 million metric tons (Council of Economic Advisors 2016; Oak Ridge National Laboratory 2015a). • With $3.1 billion, the State Energy Program supported 51,000 job-years from 2009 to 2013, and expected to lead to GHG emissions reductions of 164 million metric tons from 2009 to 2050, equivalent to taking 35 million cars off the roads for a year. It resulted in $7.7 billion in energy bill savings (Oak Ridge National Laboratory 2015a).
Public transit	• When U.S. states had the choice of where to spend ARRA transportation money, each dollar spent on public transit projects created 70% more job-hours than a dollar spent on highways (Smart Growth America 2011).
Coastal habitat restoration	• $167 million created about 17 job-years in the immediate term per $1 million spent, higher than for investments in fossil fuels. There are also longer-term benefits, including increased property values and future job creation from rebounded fisheries and tourism, and resilience to climate impacts (Edwards et al. 2013).

Notes: PV = Photovoltaics; GHG = Greenhouse gas.

Source: WRI.

Some of the more complicated infrastructure projects and research and development (R&D) investments did not pan out. A total of $3.4 billion was allocated to carbon capture and storage, but $1.3 billion of that was returned as the projects were not proceeding fast enough (Agrawala et al. 2020). Concentrated solar power projects were also not as successful as was hoped, and long-distance direct current transmission infrastructure never started construction (Varro et al. 2020). Three years after ARRA, only 8 percent of the funding for high-speed rail had been disbursed (Congressional Research Service 2020). Governors in Florida, California, and Wisconsin even returned stimulus funding for intercity railways in their states due to political opposition, despite state analysis that such projects were a sound fiscal move (Tienhaara 2018).

The emissions impact of the ARRA is uncertain. In 2009 the U.S. government projected that without the ARRA, energy-related CO_2 emissions would increase 4.1 percent from 2009 to 2019, but with the ARRA they would increase only 3.3 percent (U.S. EIA 2009). Instead of increasing, it turned out emissions decreased by 4.8 percent between 2009 and 2019, as energy efficiency improved and cheaper shale gas and renewable energy led to retirements of coal plants (U.S. EIA 2020b). It is unclear how much of the additional emissions reductions were due to the ARRA investments. There has not been an after-the-fact emissions assessment of the ARRA. The original blueprint for the stimulus package called for comprehensive carbon pricing and a removal of fossil fuel subsidies, but these policy changes did not happen, which likely minimized the emissions effects (Barbier 2011). Even today, it is estimated that the United States provides roughly $20 billion in fossil fuel subsidies per year (EESI 2019).

South Korea

South Korea invested 69 percent of its stimulus in green measures, the highest proportion in the world (Robins et al. 2010; ILO 2011; Tienhaara 2018). It announced multiple stages of stimulus, including as part of its Five-Year Green Growth Plan. It allocated $60.0 billion for green measures out of a total stimulus of $86.9 billion (Robins et al. 2010; ILO 2011; Barbier 2011; Tienhaara 2018).[9] The green measures amounted to 5 percent of South Korea's 2007 GDP. The destination of much of the green spending was unclear at the outset, as was the government's definition of what counted as green stimulus, but one attempt to classify the allocations identified $7 billion for railroads and mass transit, $6 billion for energy efficient villages and schools, $4 billion for fuel-efficient vehicles and renewable energy, and $14 billion for water management (Robins et al. 2009).

The largest project was the Four Major Rivers Restoration, but it was also the most controversial. The project built 16 dams, expanded sewage treatment facilities, and made land-use changes to eliminate river pollution from farms. It was finished by 2011, with the initial $10 billion allocation doubling to $20 billion (Tienhaara 2018). The government framed the project in terms of climate change adaptation. A government audit found that the project reduced risks of flooding and improved water quality and availability, but also led to algae growth and threatened aquatic species (Agrawala et al. 2020). Many environmental groups and academics protested the destruction of wetlands and contended that South Korea did not have a water shortage or a high risk of flooding (Tienhaara 2018; Chang et al. 2012). On the economic side, construction ramped up very quickly, which helped provide a rapid stimulus to the economy. The project was expected to be the biggest job creator among the initial stimulus spending (Barbier 2010), although it may have created fewer jobs than projected by the government (Chang et al. 2012). In addition, the majority of the jobs were low-quality and without benefits, and the rush to complete the project led to longer-than-legal working hours and 20 accidental worker deaths (Chang et al. 2012). Chang et al. (2012) performed a rough analysis and found that investments in renewable energy in South Korea made from 2003 to 2010 created more jobs per dollar and higher-quality jobs than the Four Major Rivers Restoration Project.

The South Korean economy recovered from the economic crisis faster than expected, with the green stimulus measures likely a key contributor (Mundaca and Damen 2015; OECD 2010). South Korea's economy collapsed further than the rest of the OECD, but it also rebounded faster (see Figure 8) (OECD 2020). There are several proposed reasons for this success. South Korea's stimulus was one of the largest as a share of its GDP. It was especially speedy in the distribution of its green stimulus—almost 20 percent of the funds were disbursed by mid-2009, compared to only 3 percent for most countries (Strand and Toman 2010).

It had low levels of government debt and efficient top-down governance, which allowed it to quickly set up and implement a debt-financed stimulus package (Pollitt 2011). Part of this speed was due to the Four Major Rivers Restoration Project, which had been planned and abandoned in previous years but was revived once the crisis began, so could begin quickly (Tienhaara 2018). Beyond the stimulus, other factors such as the Korean won's depreciation could have contributed to the recovery by increasing competitiveness and exports (Agrawala et al. 2020). It is difficult to disentangle what part of the growth effect came from the green measures, but given that it formed such a large component of the stimulus, it is seen as playing a positive role (Mundaca and Damen 2015). One model estimated that the green measures increased South Korea's GDP by 1 percent compared to the baseline in 2009–10 (Pollitt 2011).

The increase in the unemployment rate in South Korea from the end of 2008 to the end of 2009 was the lowest in the OECD (OECD 2010). South Korea's unemployment rate in 2009 ended up reaching only 3.6 percent, compared to projections of 4.3 percent if it hadn't been for the stimulus (OECD 2010). The Korean Development Institute did an ex post analysis of the Green Growth Plan and found that it directly created 156,000 new green jobs from 2009 to 2011. Half of the jobs were related to pollution reduction such as in recycling and waste disposal, which are sectors more likely to have poor working conditions and unstable employment (Jung 2015).

Figure 8 | **Quarterly GDP Growth in South Korea Rebounded Faster than in the Organisation for Economic Co-operation and Development as a Whole after the Global Financial Crisis**

Note: GDP = Gross domestic product.

Source: OECD 2020.

The evidence of the effect on emissions from South Korea's stimulus and Green Growth Plan is mixed. The carbon intensity of the South Korean economy (CO_2 emissions per unit of GDP) had been slowly falling before the crisis, but increased by 15 percent in 2008 and by 11 percent in 2009 because emissions remained flat while GDP went down. Carbon intensity did not fall below 2007 levels again until 2014. An ex post analysis of South Korea's Green Growth Plan found that GDP per capita remained the primary driver of CO_2 emissions levels (Sonnenschein and Mundaca 2016). Short-term investments in infrastructure, such as for railways or the Four Major Rivers Restoration Project, increased demand for resources like concrete and likely increased emissions (Sonnenschein and Mundaca 2016). Export-led growth in semiconductors and electric appliance manufacturing was also energy intensive (Agrawala et al. 2020). Little of the stimulus went to renewables, and even with the government's other renewable support policies, the share of renewable energy was still only at 1 percent in 2013, with coal at around 30 percent (Sonnenschein and Mundaca 2016). South Korea did not implement carbon pricing in combination with its stimulus package—it finally implemented an emissions trading system in 2015, with the first auctions in 2019 (World Bank 2020). Still, it is impossible to definitely say what the impact on emissions was, as there is no counterfactual for comparison and there is a potential time lag in realizing some of the positive emissions effects (Agrawala et al. 2020; Sonnenschein and Mundaca 2016).

China

In response to the global financial crisis, China quickly made infrastructure spending a priority—some green and some less so. China was one of the first economies to respond, announcing a $586 billion stimulus package in September 2008, including about $200 billion for green measures (Robins et al. 2010; ILO 2011). Almost all of the green spending was on rail infrastructure, grid modernization, and water/waste management. However, the funding was likely not as green as it appeared, as some of the railways were built specifically to enable cross-regional transport of coal (China State Council 2008). And since China's electricity was primarily from coal, grid expansions and upgrades likely benefitted coal power too. China also allocated more than $80 billion to road infrastructure (WWF 2010). About 30 to 40 percent of the total package was estimated to be new spending, with the remainder putting earlier projects on a fast track (Robins et al. 2009, 2010). The fast track was in part achieved by rolling back requirements for environmental impact assessments, which may have allowed environmentally dubious projects to proceed (Horn-Phathonothai 2009). Still, the environmental ministry suspended at least $15 billion of investments in 14 major projects after they failed environmental impact assessments (China Environment Chamber of Commerce 2009).

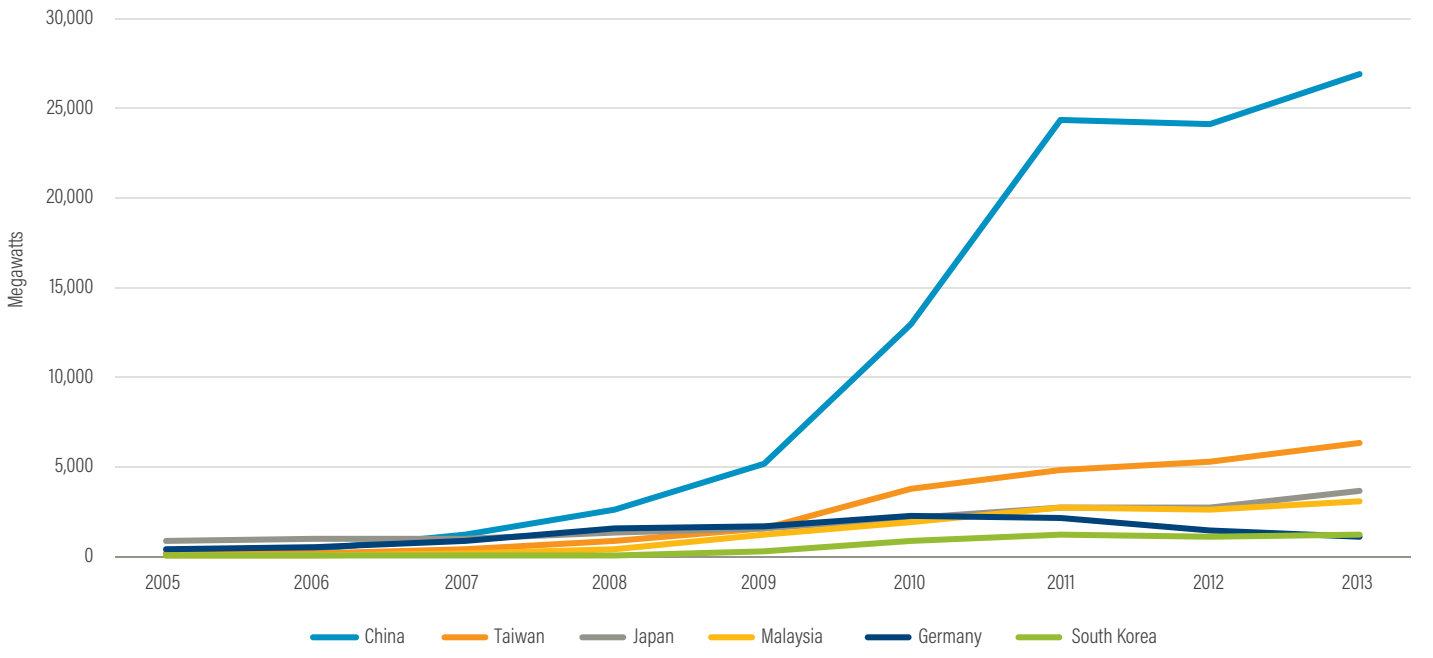
It has been difficult to determine how the money allocated to green measures was spent due to a lack of reporting by the government. We do know that there were some changes over time. The $51 billion that China originally set aside for "biological conservation and environmental protection" was later cut down to $31 billion (Horn-Phathonothai 2009). Funds allocated toward "Technological Innovation and Restructuring" doubled over the course of disbursement to $43 billion—the breakdown of the spending is not available, but it does include nuclear power, wind, solar, and new energy vehicles (NDRC 2009a, 2009b). It is unclear whether there are other inconsistences between announcements and implementation. In addition to the fiscal stimulus, China massively expanded credit, and the loans likely went to state-owned companies in polluting sectors (Horn-Phathonothai 2009).

In 2010 after the stimulus, China's economy bounced back to double digit growth, close to pre-crisis levels. Growth reached 11.9 percent in the first quarter of 2010, compared to 6.1 percent in the first quarter of 2009. Employment in infrastructure helped make up for job losses in export-oriented industries, so while employment and wage growth slowed in 2009, they remained positive (World Bank 2010). A 2011 ex post model estimated that green investments were responsible for an increase in GDP of 4.2 percent above the baseline in 2009 and 3.6 percent above the baseline in 2010, mostly from the investment in rail and grid networks (Pollitt 2011). However, in the following years the stimulus created high debt burdens for local governments and led to overcapacity in steel, cement, and glass (M. Zhang et al. 2019; European Chamber 2016).

The stimulus increased China's environmental footprint in the short term and slowed its transition away from heavy industry, though investments in railways were projected to decrease longer-term energy consumption. Because so much of China's stimulus was focused on heavy infrastructure like railways and highways, early on it mainly benefitted cement, iron, and steel producers (Horn-Phathonothai 2009). From 2008 to 2009, cement production increased 15 percent and crude steel production increased 14 percent (National Bureau of Statistics of China 2010). The effect of the stimulus on energy consumption was projected to turn from negative to positive by 2014, with energy use in the transportation sector (including railways) 20 percent lower in 2020 compared to a baseline without the stimulus (WWF 2010).

During the crisis, China enhanced its efforts to establish itself as the world leader in renewable energy, particularly solar. China provided $30 billion in credit to solar manufacturers, subsidized grid connected and off-grid solar, and implemented a nationwide solar feed in tariff (S. Zhang et al. 2014). Though not part of the stimulus package, these measures still arose as part of the government's strategy to recover from the crisis. Due to these and other policies, China's solar manufacturing capacity increased by a factor of 20 between 2007 and 2011 (see Figure 9). China now has more wind and solar capacity than any other country (REN21 2020). There were worldwide benefits as China's investments dramatically reduced the cost of solar photovoltaics (PV). China's solar policies were not without complications though: the rapid developments and influx of credit led to overcapacity in the manufacturing sector, high levels of debt, and distortions in the solar energy market (S. Zhang et al. 2014). China also invested heavily in the manufacturing of new energy vehicles, including electric vehicles—establishing new standards and goals in 2009 that would set it up to become the world's largest electric vehicle producer (Gong et al. 2012).

Figure 9 | **Annual Solar Photovoltaics Cell Production by Country**



Source: Earth Policy Institute 2015.

European Union

The vast majority of the EU's 2008 stimulus was spending by member states. France, Germany, and the United Kingdom allocated the most to green spending, totaling $25.7 billion collectively. In addition, about $24.7 billion of the $38.8 billion stimulus from the EU budget and EU banks was allocated to green measures (Robins et al. 2010; ILO 2011). Though they weren't technically part of the green stimulus, several EU countries raised feed-in tariffs for solar and wind in the same time period, worth $93 billion, more than any of the fiscal stimulus measures (Varro et al. 2020). Like in the United States, carbon capture and storage (CCS) demonstration did not advance quickly. Only one of the six pilot projects was completed even though €424 million ($589 million) of the €1 billion ($1.47 billion) allocated for CCS was spent (European Commission 2018).

An assessment based on macroeconomic modeling and quantitative and qualitative analysis found that the green elements of the stimulus packages had a small positive impact on European countries' economies in the short run. Each $1 in green investment boosted GDP by $0.60 to $1.10 at the national level and up to $1.50 at the European level. Most of the green investment policies also led to higher employment levels (Pollitt 2011). Many of the EU member states were able to start spending the money they allocated within weeks of the announcements, and the majority of all policies were implemented in a timely matter, though it was faster to make tax changes and introduce car scrappage schemes than it was to implement investment projects like high-speed rail (Pollitt 2011).

The environmental impact of the green stimulus measures was small, but likely net positive in the long run. Based on the same study, green stimulus interventions in European countries had a negative environmental impact in the short term because they increased economic activity. But in the long term as energy demand was reduced, the environmental benefits were expected to outweigh the costs. Investments in renewable energy and energy efficiency had the longest-lasting environmental effects, while the environmental impacts of new rail transport infrastructure were harder to measure (Pollitt 2011).

In Germany, green investments accounted for roughly 13 percent of the total $105 billion stimulus (Robins et al. 2009; ILO 2011). The building refurbishment initiative received €3.3 billion ($4.6 billion) and was one of the largest programs. An ex ante analysis estimated the spending on buildings would be paid back via reduced energy costs and could lead to 25,000 jobs in manufacturing and construction (Meyer-Ohlendorf et al. 2009). Germany also implemented a €5 billion ($7 billion) car-scrapping scheme, which successfully stimulated the automobile industry but also increased emissions (see Box 2). A small part of Germany's stimulus was invested in the country's Renewable Energy Sources Act, which was implemented in 2009 with the goal of doubling renewable energy's share to at least 30 percent by 2020. Most of Germany's support for renewables came through feed-in tariffs and other non-stimulus policies (Barbier 2009; Robins et al. 2010; ILO 2011). Germany met its goal and reached more than 40 percent renewable power in 2019 (Eckert 2020).

The amount of France's stimulus plan that went to green measures is debated, and estimated at anywhere from 8 to 20 percent of its €26 billion ($34 billion) French Economic Revival Plan. The stimulus included green investments in solar PV, building efficiency, and railroads, but also spending on fossil fuel plant upgrades and road infrastructure. Much of the funding was not earmarked for specific projects, which made accounting for the green elements difficult (Pollitt 2011). Also in 2009, France passed the first law of the Grenelle de l'Environnement, a framework defining the conditions for sustainable development and enhanced environmental measures in 13 sectors. The different green measures of the stimulus package were financed alongside the priority areas defined in this framework (Barbier 2009).

A modest 5 to 7 percent of the United Kingdom's total £25 billion ($41 billion)[10] stimulus was allocated for green stimulus measures such as energy efficiency and rail transport. The £100 million ($161 million) spent on the Warm Front Program in 2009–10 installed insulation and heating improvements in almost 38,000 homes, saving each up to £300 in energy bills every year (Pollitt 2011). A small

amount was also spent on social housing, one of the very few European stimulus investments to go directly to vulnerable groups. One of the first neighborhoods to participate in the program saw $1.46 in social value per $1 invested (Nottingham Trent University 2013). However, the green investments were also offset by negative investments like increasing capacity on highways and R&D in fossil fuels (Robins et al. 2009; Hohne et al. 2009).

HOW THE COVID CRISIS IS DIFFERENT

While the current COVID-19 crisis might bear some resemblance to the Great Recession of 2008 and 2009, it is fundamentally different. The Great Recession started because of internal financial factors in the economy. Then, there was a classic "output gap" between what the economy could produce and what it was producing; the economy was intact, but credit markets were frozen. This crisis, in contrast, is both a health and an economic crisis. It has been precipitated by an exogenous shock (the pandemic) that has then resulted in a massive reduction in both supply and demand as the entire economy has been placed in something akin to a medically induced coma. By April 2020, an estimated 81 percent of the global workforce had been hit by full or partial lockdown measures (del Rio-Chanona et al. 2020; ILO 2020). The magnitude of the current COVID-19 crisis is significantly larger than of the Great Recession; the IMF projected in June 2020 that the global economy would shrink 4.9 percent in 2020 and would affect both advanced (-8 percent) and emerging market and developing countries (-3 percent) alike. In 2009 the global economy shrank only 0.1 percent, while developing and emerging market countries continued to grow (IMF 2020). Moreover, unlike 2009, uncertainty about disease dynamics and the course of the pandemic may mean several waves of lockdown measures that cause ripples of economic recession. In addition, debt in emerging and developing markets has grown to a historic high over the past decade, in some cases causing hesitation around large fiscal stimulus (Kose et al. 2020).

On the positive side, the situation in green economy sectors has improved today compared to 2008–09. Prices for low-carbon technologies have fallen dramatically: solar PV by 85 percent, wind by 49 percent, lithium batteries by 79 percent—all since 2010, and LED lights by 85 percent since 2012 (BNEF 2019; DOE 2017). Non-hydroelectric renewable generation worldwide has more than trebled since 2009 (US EIA 2020a). With prices low, this is the time to invest more in renewable energy as well as to help drive down the costs in emerging technologies, such as electricity storage, electric trucks, and zero-carbon buildings. We may be underestimating their potential for cost declines, as was the case with renewables in the past (Arndt et al. 2018).

The fate of the oil industry is not certain. Oil futures for May 2020 went negative temporarily—a historic first. While prices have rebounded to around $43 a barrel in August (Figure 10), they remain relatively low and there is uncertainty about future oil demand and the degree of the economic rebound in the next few years. Sustained low oil prices will seriously impact the viability of many oil projects. Global consultancy group Wood Mackenzie estimates that with oil prices at $35 per barrel, 75 percent of proposed oil and gas projects don't cover their cost of capital, and rates of return are in single digits (Holland

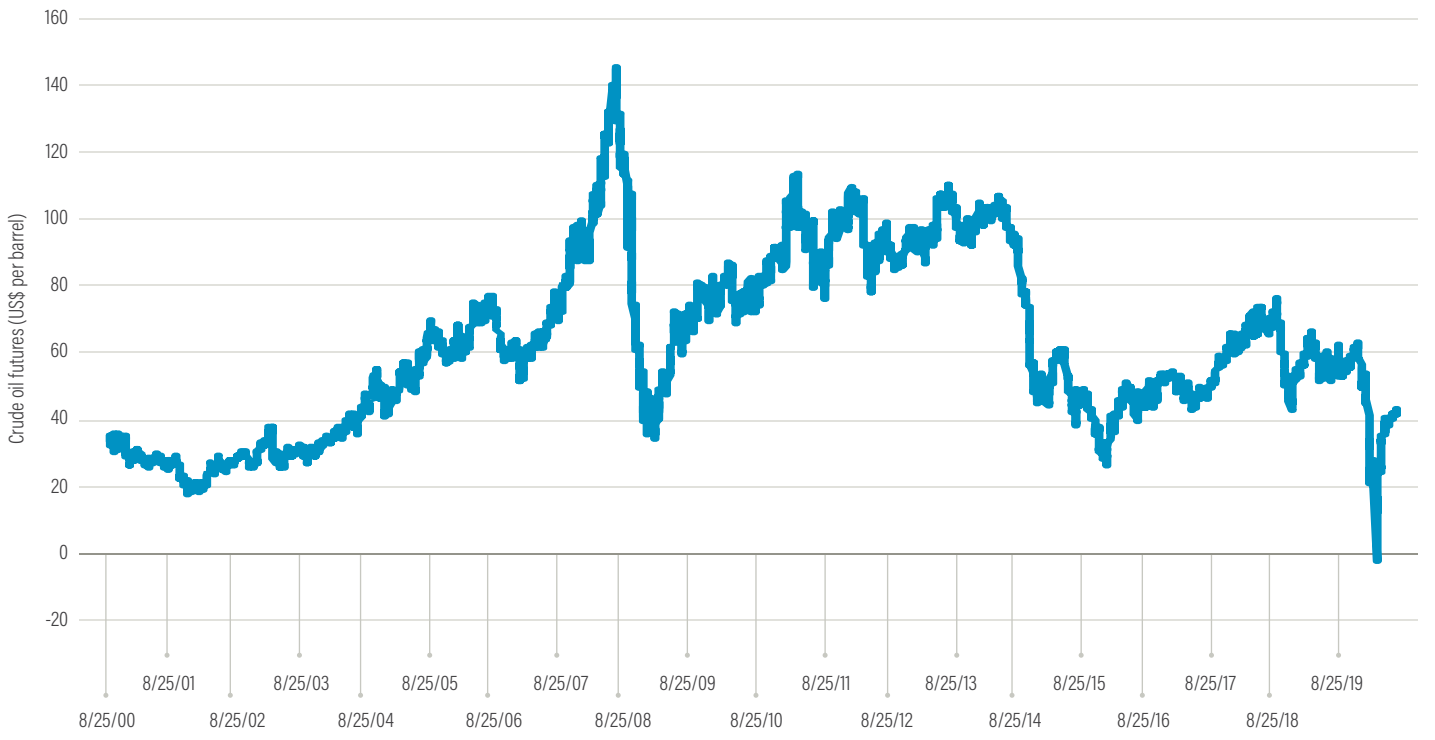
Box 2 | Car-Scrapping Schemes: A Cautionary Tale

Eight of the top ten largest car-producing countries introduced "cash for clunkers" to support their ailing auto industries. While these car-scrapping schemes were often touted as green stimulus, subsequent evaluations found that they had only a modest stimulus effect and did not reduce emissions as had been hoped (Schweinfurth 2009; Klößner and Pfeifer 2015). In the United States, for example, car buyers simply moved their purchases forward in time, so additional car sales due to the program were offset the following year after the program ended and sales went down (Mian and Sufi 2012). Each job created under the U.S. program took $1.4 million, much higher than alternative fiscal measures (Gayer and Parker 2013; Agrawala et al. 2020). Germany was the only country to see a large and lasting increase in car sales due to a car-scrapping scheme, with 1.3 million new car registrations due to the program, including almost 1.0 million that were not pulled forward from future periods. However, this actually increased CO_2 emissions by 2.4 million tons (Klößner and Pfeifer 2015). Reviews of the programs across all countries find that the discarded cars were not necessarily being replaced with the most efficient alternatives (Hohne et al. 2009; IARC 2014). Any emissions reductions were small and ended when the programs were over (Wee et al. 2011).

2020b). Moreover, fossil fuel companies are loaded with debt: North American oil and gas producers have a combined $86 billion in debt coming due in the next four years (Holland 2020a). The COVID-19 crisis may fundamentally restructure the oil industry and present more opportunities for the expansion of clean energy.

The relatively low oil prices for consumers also present an opportune moment to reduce fossil fuel subsidies and raise or enact new carbon pricing, particularly through the use of revenue-neutral carbon fees. Current low fuel prices mean the impact of carbon pricing on consumers will be smaller, although in some countries, unemployment remains high and reforms will have to be enacted cautiously. Countries will need to avoid the temptation to revert back to old policies when prices rise again as economies recover. In 2009, the G20 promised to phase out fossil fuel consumption subsidies. However, in 2019 global fossil fuel subsidies were still at $477 billion (OECD and IEA 2020). Only a subset of countries have made significant (e.g., Indonesia) or modest reforms (e.g., Mexico, Germany) (Barbier 2019; OECD 2017a, 2017b, 2018a). In 2019, there were 57 regional, national, and subnational carbon pricing initiatives implemented or scheduled for implementation; yet, about half of the emissions covered by carbon pricing initiatives are still priced below $10/ tCO_2e (World Bank 2019).

Figure 10 | The Price of Crude Oil Futures



Note: New York Mercantile Exchange West Texas Intermediate crude oil futures.

Source: Macrotrends 2020.

RECOMMENDATIONS

Drawing on the lessons from this paper and its case studies, the following are recommendations for governments to implement green stimulus as part of the COVID-19 recovery. Countries around the world have a chance to build back better after COVID-19 by designing stimulus packages that quickly create jobs and improve the economy, while also providing climate and social cobenefits.

- Governments should prioritize green investments that have strong economic and social benefits and have the potential to reduce emissions rather than prioritize fossil fuel investments. Existing ex post evaluations as well as our case studies find that the green elements of stimulus packages generally boosted economies and increased employment. Green investments often have higher employment multipliers than fossil fuels and will not lock in future emissions. Some green infrastructure projects can be implemented quickly to boost the economy now while other investments like research and development can create longer-term engines of growth. Governments should make sure workers receive fair wages and should support fossil fuel communities in transition.
- Governments should be as specific as possible about what interventions they consider "green" and what types of projects will be financed. Definitions of green finance should be rigorous and internationally consistent where possible. The EU taxonomy for sustainable activities would be a good example to follow. After stimulus measures are announced, governments should continue to provide information about how the money is disbursed.
- Governments should focus on technologies that are ready for expansion and on projects that can scale up quickly, such as energy efficiency retrofits, while avoiding untested technologies like carbon capture and storage and more complicated infrastructure projects that could run into planning difficulties, like high-speed rail. Where possible, governments should focus on scaling up existing projects rather than designing new ones.
- Stimulus should be accompanied by other policies and fiscal reforms, such as phasing out fossil fuel subsidies and use, introducing carbon pricing, and setting emissions targets and standards. The experience from the Great Recession shows that stimulus alone cannot set the world on a trajectory for a net-zero emissions economy, though it can help build up the low-carbon infrastructure that forms the foundation for that economy.
- Development bank finance should prioritize green investments in future stimulus packages, especially green and sustainable infrastructure. Development banks should make sure policy-based and financial intermediary lending at least "do no harm" and preferably are climate-positive, as these two instruments are expected to be major foci during the COVID-19 response. Moreover, development banks should encourage recipient countries to enact jobs programs that have strong climate cobenefits, such as nature-based solutions.
- Central banks should set up green asset purchase programs. Central bank quantitative programs that allocate purchases according to the makeup of the market are not "neutral" and in fact give preference to emissions-intensive sectors and companies.
- Governments should undertake more monitoring and evaluation than they did in 2008–09 stimulus packages and plan for ex post assessments to understand the economic and environmental impacts of different stimulus measures. These evaluations should consider the net life cycle effects of economic and emissions changes rather than the gross effects. There need to be more counterfactual analyses that compare a scenario with the stimulus to a scenario without it. These assessments can help with decision-making while projects are being implemented and produce valuable information for future investments.

- Sector-specific recommendations:
  - Governments can invest in building efficiency programs to create jobs, reduce emissions, and save households money. They work best by ramping up existing programs and providing comprehensive retrofit options that could be tailored for individual home needs.
  - While public transit ridership is down because of the COVID pandemic, public transit investments can be a quick way to create jobs and support the future economy. Walking and cycling investments have also proved to have high employment multipliers.
  - Investing in renewables can create jobs, build new industries, and reduce technology prices. Renewable energy investments are an even more attractive investment today than in 2008–09, and governments can also invest in clean energy manufacturing and research in the next generation of technologies, like green hydrogen and batteries.
  - Governments, especially in low- and middle-income countries, can turn to nature-based solutions more, making sure to conduct environmental assessments beforehand. Nature-based solutions like habitat restoration were largely untapped after the global financial crisis, but the results were promising.
  - Governments should steer clear of car-scrapping schemes, which in the past have only had a modest stimulus effect and did not reduce emissions as much as was hoped.

ENDNOTES

1. Assuming exchange rate of £1 to $1.6071 in 2012.
2. Assuming exchange rate of €1 to $1.39 in 2009.
3. Assuming average exchange rate of $1.47 and $1.39 to €1 in 2008 and 2009, respectively.
4. Assuming an average exchange rate of $0.1457 to 1 Renminbi (Matisoff 2012).
5. Includes international financial institutions (IFIs), United Nations (UN) agencies, and other multilateral funds.
6. The other being the $3 billion Countercyclical Support Facility (established in June 2009), in addition to regular loan and technical assistance products.
7. This is not to suggest that low-carbon and climate-resilient development is not important for these sectors, but the degree to which climate is mainstreamed in these sectors cannot be assessed from high-level sectoral data.
8. Beyond the ARRA, the United States spent another $24 billion on green measures through the Emergency Economic Stabilization Act in 2008 and $4.9 billion for budget increases for 2010.
9. Data from (Robins et al. 2010)—cited in (ILO 2011) and others—put the percentage of Korean green stimulus to total stimulus at around 80 percent, but those data do not include a $10.9 billion non-green stimulus that Korea announced in November 2008 (Wassener 2008; Tienhaara 2018).
10. Assuming exchange rate of £1 to $1.62 in 2009.

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ABOUT THE AUTHORS

Joel Jaeger is a Research Associate in the WRI Climate Program. In addition, he works on the New Climate Economy project and with the WRI US team.

Michael Westphal was a Senior Associate in the Sustainable Finance team. He also worked on the New Climate Economy project and with the Ross Center for Sustainable Cities and the Coalition for Urban Transitions.

Corey Park is a Research Specialist to the Executive Vice President and Managing Director at WRI.

ABOUT WRI

The World Resources Institute is a global research organization that turns big ideas into action at the nexus of environment, economic opportunity, and human well-being.

Our Challenge

Natural resources are at the foundation of economic opportunity and human well-being. But today, we are depleting Earth's resources at rates that are not sustainable, endangering economies and people's lives. People depend on clean water, fertile land, healthy forests, and a stable climate. Livable cities and clean energy are essential for a sustainable planet. We must address these urgent, global challenges this decade.

Our Vision

We envision an equitable and prosperous planet driven by the wise management of natural resources. We aspire to create a world where the actions of government, business, and communities combine to eliminate poverty and sustain the natural environment for all people.

Our Approach

COUNT IT

We start with data. We conduct independent research and draw on the latest technology to develop new insights and recommendations. Our rigorous analysis identifies risks, unveils opportunities, and informs smart strategies. We focus our efforts on influential and emerging economies where the future of sustainability will be determined.

CHANGE IT

We use our research to influence government policies, business strategies, and civil society action. We test projects with communities, companies, and government agencies to build a strong evidence base. Then, we work with partners to deliver change on the ground that alleviates poverty and strengthens society. We hold ourselves accountable to ensure our outcomes will be bold and enduring.

SCALE IT

We don't think small. Once tested, we work with partners to adopt and expand our efforts regionally and globally. We engage with decision-makers to carry out our ideas and elevate our impact. We measure success through government and business actions that improve people's lives and sustain a healthy environment. Maps are for illustrative purposes and do not imply the expression of any opinion on the part of WRI, concerning the legal status of any country or territory or concerning the delimitation of frontiers or boundaries.