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"Green Stimulus," Economic Recovery, and Long-Term Sustainable Development

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Abstract

This paper discusses short-run and long-run effects of "green stimulus" efforts, and compares these effects with "non-green" fiscal stimuli. Green stimulus is defined here as short-run fiscal stimuli that also serve a "green" or environmental purpose in a situation of "crisis" characterized by temporary under-employment. A number of recently enacted national stimulus packages contain sizeable "green" components. The authors categorize effects according to their a) short-run employment effects, b) long-run growth effects, c) effects on carbon emissions, and d) "co-benefit" effects (on the environment, natural resources, and for other externalities). The most beneficial "green" programs in times of crisis are those that can stimulate employment in the short run, and lead to large "learning curve" effects via lower production costs in the longer term. The overall assessment is that most "green stimulus" programs that have large short-run employment and environmental effects are likely to have less significant positive effects for long-run growth, and vice versa, implying a trade-off in many cases between short-run and long-run impacts. There are also trade-offs for employment generation in that programs that yield larger (smaller) employment effects tend to lead to more employment gains for largely lower-skilled (higher-skilled) workers, so that the long-term growth effects are relatively small (large). Ultimately, the results reinforce the point that different instruments are needed for addressing different problems.

This paper—a product of the Environment and Energy Team, Development Research Group—is part of a larger effort in the department to investigate effective policy responses to the crisis. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The author may be contacted at jstrand1@worldbank.org.

"Green Stimulus," Economic Recovery, and Long-Term Sustainable Development

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"Green Stimulus," Economic Recovery, and Long-Term Sustainable Development

1. Introduction

The current worldwide economic crisis, starting in the latter half of 2008, has led to substantial discussion of new ideas on how to best emerge from the crisis situation. One set of ideas has been advanced under the general heading of "green stimulus" or a "green new deal". This has become a somewhat imprecise catch phrase for various proposals to undertake economic stimulus activities that at the same time are seen to have advantageous environmental and economic growth effects. In that context, there has been particular emphasis on clean-energy investments that will expand demands for labor and other factors of production in the near term (the stimulus), while providing longer-term environmental benefits including mitigating greenhouse gas (GHG) emissions and, potentially, enhanced economic growth. Various green stimulus plans have been promoted by higher-income countries including the United States and Europe, as well as some middle-income countries, as discussed below.

Several overlapping arguments have been offered in support of green stimulus programs, all of which in one way or another emphasize the "green" aspect. One argument is that particular green stimulus activities can have equal or greater effects on job creation and near-term economic activity compared to other stimulus activities. In other words, the activities are seen to be "win-win" in terms of recovery from the crisis and putting in place more environmentally sustainable investments for the longer term. Another argument holds that with a presumption of greater global demand over time for various forms of "green technology," green stimulus investment now can provide a "first mover" advantage that will allow the country to take a stronger competitive position in meeting that demand. In this case, the activities are seen to be win-win with respect to environmental protection and economic advance over the longer term, in addition to whatever short-term stimulus effects are provided.

Other arguments are related to the political economy of environmental policy. A worry is that the crisis may lead to a "return to basics" in some countries, with environmental (including climate change) concerns receding into the background in terms of political interest, while shorter-run targets to increase jobs and economic output take on a disproportionate central role. A related argument for green stimulus is that political economy considerations prevent the imposition of appropriate direct policy measures for internalizing climate change and other environmental externalities over the longer term. The promotion of green projects on short-term stimulus grounds may then be a second-best alternative from an environmental perspective as well, in particular if it helps to reduce "locking in "more emissions-intensive and less clean capital stock in the longer run.

These arguments, emphasizing multiple benefits resulting from the application of a single policy instrument, obviously need some empirical substantiation to be persuasive. Conceptually, they may appear to contrast with the basic principle of efficient economic policy design which states that to most efficiently address multiple policy targets, one needs to have separate policy instruments each directed at one specific target.[1] It is here important

[1] This principle of efficient economic policy design is given by the so-called Tinbergen rule, which states that efficiently attaining particular targets for n economic target variables requires n independent instruments (or policy variables). See Tinbergen (1952); Tinbergen's development of this principle was important for his Nobel

that the instruments operate independently, which means that they are not duplicative but work in different ways on the economic variables of interest.

In this paper we review various arguments for green stimulus, in particular as they might apply to developing countries, given their lower incomes relative to advanced industrialized countries. We focus in particular on arguments for why some categories of "green stimulus" activity may have less of a stimulus impact than other (green or non-green) such activity; and why some activities labeled green stimulus may have positive employment and environmental impacts, but mainly over a longer term. Conceptual arguments are buttressed by the limited numerical information currently available for making such judgments.

Because both theory and evidence remain limited, our conclusions are somewhat tentative. Nevertheless, we find reasons to conclude that the immediate stimulus effect of many proposed green stimulus measures may be fairly limited relative to other available alternatives. Multiple benefits more likely may be found in infrastructure and other investments that help enhance longer-term economic growth and environmental sustainability – though there are still tradeoffs in this realm as well. There are categories of spending that can have a more significant short-run stimulus effect, while also contributing to various "green objectives." Examples are in the areas of environmental cleanup activities, in energy-efficiency retrofits, and in increased efforts to monitor and deter illicit extraction of natural resources such as forests and biological species.

On this reasoning, stimulus efforts should focus more on measures that are effective at increasing aggregate demand and employment in the short run, taking into account their potential impacts on longer-term environmental and economic trends as well. Longer-term economic growth and environmental sustainability should be advanced mainly by distinct but complementary measures. In composing portfolios of shorter-term and longer-term measures, the balance between more or less "green" investments or other expenditures should reflect the social values ("shadow prices") of environmental damage or improvement, relative to the economic opportunity cost.

Our analysis leaves open various questions about the near-to-medium term economic sustainability of some green investment components in stimulus packages. Many assessments of the job-creation and growth-promotion opportunities from clean energy investments, even by those advocating those investments, provide more evidence on longer-term versus short-term opportunities. That leads in turn to unresolved questions about the ease with which the outcomes of clean energy investment can be achieved when one considers economies not in the troughs of recession. In addition, a number of assessments underscore, deliberately or implicitly, the need for stronger public policies to increase demand for clean energy investment over the medium term. This is because many clean energy investments are not yet cost-competitive with conventional energy sources solely on the basis of private-market costs; those cost differences will not be closed until there is further innovation and learning-by-doing through increased use of clean energy induced by policy; and current policy does not yet provide sufficient impetus for an economically efficient scaling-up of clean energy.

We hasten to add that the above remarks are *not* arguments against clean energy initiatives. As noted above, the economic value of such benefits needs to reflect the potential environmental gains as well as the costs of supplying clean energy. That said, however,

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Prize award (with Ragnar Frisch) in 1969, the very first for economics. See also the textbook treatment by Johansen (1965).

"green" development in the medium or long run is impossible to achieve without micro units (households and businesses) facing appropriate price signals. A greater public-induced supply of "green" goods is only part of the story and not by itself sufficient or sustainable. In the concluding section of the paper we argue that reforms of price distortions that work against green investment and consumption patterns are crucial not only in the longer term, but also in the context of short-term stimulus.

A further initial warning should also be given, related to the use of fiscal policies for short-run activity regulation in developing countries more generally. As argued by Kraay and Serven (2008), fiscal policies particularly in lower-income developing countries tend to be pro-cyclical, for various political and economic reasons; are difficult to reverse; and may have limited stimulus effect in the short run. While this may leave one somewhat pessimistic about the prospect of using fiscal policies to stimulate LIC economies, it does not affect our main argument here, which relates to the relative degree of "greenness" that is desirable in a given fiscal policy.

2. Some Implications of the Economic Crisis for Environmental and Natural Resource Management and Quality

As an additional backdrop for a discussion of green stimulus, it may be helpful to consider impacts of the current economic downturn on the quality of the environment and on natural resource management. In terms of the crisis, most attention has so far been drawn to reduced overall economic activity and employment. The crisis also is likely to have impacts on the management and exploitation of environmental and natural resources in many developing countries. However, these impacts will depend on a variety of factors.

For example, a crisis that dramatically reduces urban employment opportunities may lead to return migration to rural areas, and for some back to farming, and increase the rate of rural poverty.[2] This may result in additional pressure to deforest through agricultural expansion by poor and subsistence farmers.[3] Another main avenue is via commercial logging, and crisis-induced changes in prices and terms of trade. Heavy devaluations, experienced by some countries in crisis (as exemplified by Indonesia in the 1997-1998 East Asia crisis), may make increased logging more lucrative. On the other hand, timber prices are likely to drop during a global recession, which may work in the opposite direction.[4] The fiscal regime, for public management of forest extraction and related revenues, could here be central.[5]

Crises also may affect environmental quality in developing countries, but these potential effects can be complex and dependent on certain initial conditions in specific countries. One factor is environmental regulation. In countries with a relatively high degree of regulation, the crisis could lead to environmental deterioration if the enforcement of standards is weakened in an effort to reduce the impacts of the crisis. Where there is relatively little effective environmental regulation, on the other hand, the crisis could lessen pressure on the

[2] See Barbier (2004), Deininger and Minten (2002) for studies of the relationship between poverty and deforestation in LICs.
[3] Dauvergne (1999) showed that the 1997-1998 East Asia crisis led to increased deforestation, and laxer enforcement of forest laws, in Indonesia. From Pagiola (2001), there were no similar effects for Thailand nor the Philippines; these countries were however much less seriously hit by this crisis.
[4] See World Bank (1999); and Wunder (2003) where the main argument is that exogenous positive (negative) wealth shocks to a country could dramatically reduce (increase) deforestation.
[5] See the discussion in World Bank (2003).

environment due to reduced economic activity. However, these influences are difficult to separate out from other factors such as the effects of the crisis on the composition of output, and ongoing trends in the composition of energy consumption.[6]

3. Defining "Green Stimulus"

We propose the following definition:

Green stimulus is 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 longer-term.

This definition is wide and applies to outcomes rather than to instruments used to achieve the outcomes. The focus in the definition is on measures to increase short-run economic activity with lasting beneficial environmental impacts. The fundamental underlying premise is that "win-win" outcomes could be achieved through such policies.

Any long-run effects that green stimulus policies have for the environment and natural resources, and for growth, must clearly be taken into account when evaluating the effects of the stimulus. Positive co-benefits will add to the attractiveness of "green stimulus" policies.

We denote green stimulus activities conceived of in terms of increased spending on green activities and commodities as *direct green stimulus*. The increased spending could be undertaken by the government or by the private sector in response to targeted subsidies or tax incentives. This will be the main object of our discussion in this paper. Such activities can be contrasted with *indirect green stimulus* activities, which consist of policies that work through the price mechanism, including changes in broader-based taxes or fees and "green tax swaps". Such policies could imply that revenue raised from, say, increased environmental taxes or fees can be applied by the government to increase activity elsewhere in the economy, green or otherwise; or they could be refunded to households and/or businesses through reductions in other taxes or fees.[7]

We further distinguish among different categories of direct green stimulus. One would be current spending on activities seen as "green," e.g. environmental cleanup or production of renewable energy. A second is investment in the environment and natural resources through protection or restoration activities, including retrofits for pollution reduction and prevention and improved socio-economic resilience to climate change. A third category is comprised of new investments in traditional physical or human capital, including for infrastructure, designed to yield significant environmental or climate change co-benefits.[8]

Some key questions with respect to setting priorities for near-term stimulus and longer-term investment are:

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[6] These issues are addressed by López (2009). While these linkages are logically plausible, more research is required to investigate them empirically.

[7] Non-fiscal measures such as changes in energy utility regulation also could have positive environmental impacts, depending on their nature.

[8] Infrastructure design is a significant driver of carbon emission; poor infrastructure design can commit society to high levels of emissions for long future periods; see Shalizi and Lecocq (2009); Strand (2009b); World Development Report 2010, Chapter 4 (World Bank 2009c).

(1) In the context of short-term stimulus, what is the degree of complementarity between short-term macroeconomic goals (increased effective demand and employment), and longer-term environmental and natural resource benefits? Win-win opportunities likely depend on strong complementarities. On the other hand, there may be tradeoffs between investments that give greater economic "kick" and those that set in motion greater environmental benefits over the longer term.

(2) Similarly, what is the degree of complementarity between investments that most enhance prospects for long-term growth, and those that lead to greater long-term environmental benefits? Here, a new investment or an extension of a near-term stimulus investment is more attractive when complementarities are stronger.

(3) In combining points 1 and 2, one may ask, what are prospects for realizing "triple-benefits" – short-term stimulus, longer-term growth, in addition to lasting environmental and natural resource benefits – when considering alternative expenditure plans? Alternatively, there may be fewer cases with significant overlap between green stimulus (maximum expansionary policy impacts with environmental co-benefits) on the one hand, and longer-term investment with green co-benefits on the other. One example would be short-term green investments which are not economically sustainable over the longer term, so that the environmental gains are more ephemeral or the investments require costly ongoing subsidization. Another example would be green stimulus measures that have weaker impacts on short-term output or employment than alternatives – though then one also needs to consider if the alternatives would tend to lock in less green trends for long-term growth.

4. Structure of Green Items in Recently Developed Stimulus Packages

We next consider in somewhat more detail some of the stimulus packages that have been proposed by key countries. These focus primarily on direct stimulus.

Table 4.1 indicates the scope and types of green stimulus as part of larger stimulus packages. Overall, out of an identified proposed stimulus spending of US$2.8 trillion, about US$435 billion (about 15 percent) has been classified as "green." Much of the proposed "green" spending is in high-income countries, along with China and South Korea. China has the largest overall "green" package; and South Korea's shows the largest "green" share of any proposed package.

Note that much of the proposed "green" spending (more than two-thirds of the total; and for China almost 100 percent) is for heavy infrastructure including rail, power grids, and water and sanitation.[9] This highlights the issue of how to define "greenness" of different expenditure components. For example, in reducing carbon emissions, rail investments may have substantial positive impact, but mainly in the longer run; grid investments support rapidly growing electricity consumption and may increase emissions, depending on the extent to which the investments also improve the efficiency of transmission (reduce line losses). On the other hand, for increasing the population's access to a sustainable water resource base and

[9] OECD (2009) contains a similar table but with different classifications of items. The "green" parts of stimulus for countries such as China and Korea are here drastically lower than in Table 4.1. The reason is a much more restrictive definition of green, which in particular excludes infrastructure investment that is not directed explicitly at the environment.

to clean water in particular, water sector improvements would be more valuable.[10] It is also difficult from the figures to immediately know how much infrastructure investment is replacement of old infrastructure, with no major environmental improvements; and how much is new infrastructure with green characteristics but also stimulates negative impacts by alleviating bottlenecks in the economy. More obviously carbon-reducing activities, including increased building efficiency and low-carbon vehicles, also play a role (albeit mainly in high-income countries).

[10] The effect of water sector investments on emissions will depend on factors including the energy efficiency of pumps and treatment equipment, the reduction in water waste vis-à-vis the increase in water supply; and the effects on methane emissions of different treatment options.

Table 4.1: Summary of Current Direct Stimulus Programs (March 2009), and their "Green" Components

				Power		Energy Efficiency				
Country	Total stimulus (in $US billion)	"Green" Stimulus(in $US billion)	"Green Stimulus" (%)	Renewable	CCS/Other	Building Efficiency	Low carbon vehicle	Rail	Grid	Water/ Waste
Australia	26.7	2.5	9.3	-	-	2.48		-		-
China	586.1	221.3	37.8	-	-	-	1.5	98.65	70	51.15
India	13.7	0	0	-	-	-	-	-	-	-
Japan	485.9	12.4	2.6	-	-	12.43	-	-	-	-
South Korea	38.1	30.7	80.5	-	-	6.19	-	7.01	-	13.89
Thailand	3.3	0	0	-	-	-	1.8	-	-	-
EU	38.8	22.8	58.7	0.65	12.49	2.85	1.94	-	4.86	-
Denmark	-	1.8	-	0.9	-	-	0.9	-	-	-
Germany	04.8	13.8	13.2	-	-	10.39	0.69	2.75	-	-
France	33.7	7.1	21.2	0.87	-	0.83	-	1.31	4.13	-
Italy	103.5	1.3	1.3	-	-	-	-	1.32	--	-
Spain	14.2	0.8	5.8	-	-	-	-	-	-	-
UK	30.4	2.1	6.9	-	-	0.29	1.38	0.41	-	0.83
Other EU states	308.7	6.2	2	1.9	-	0.4	3.9	-	-	0.03
Canada	31.8	2.6	8.3	-	1.08	0.24	-	0.39	0.79	0.13
Chile	4	0	0	-	-	-	-	-	-	-
US	972	112.3	11.6	32.78	6.55	30.74	4.76	9.92	11.92	15.58
Total	**2,796.00**	**436**	**15.6**	**38**	**20.1**	**66.8**	**15.9**	**121.8**	**91.7**	**81.6**

Sources: Robins, Clover and Singh (2009); HSBC (2009); Jones (2009); Barbier (2009).

5. Conceptual Arguments on Effectiveness of Green Stimulus

Table 5.1 below provides a first-cut conceptual categorization of different spending and activity, in terms of their principal effects. The table encompasses both "direct" and "indirect" green stimulus activities. We consider three categories of green stimulus policies, each discussed below. The first column indicates the potential for short-term stimulus effects, on the assumption that there is under-employment of labor and other factors of production. These effects would tend to taper off as the economy moves toward full employment. The other three columns are concerned with longer-term effects. The longer-term growth effects will depend on the efficiency of the investments themselves and on what other uses of resources might be crowded out.

Environmental cleanup, energy efficiency retrofits, and at least some natural resource maintenance and safeguarding measures are likely to have reasonably strong stimulus effects as well as significant positive effects on environmental and natural resources. Local environmental effects of bio-energy expansion and carbon sequestration will depend on the specific impacts on land and other natural resources and on the environmental characteristics of the fuel use. Effects on overall economic growth are likely to be limited except in cases

where improved energy efficiency has a substantial impact on total energy expenditure (or potentially where resource contamination has a very widespread effect on productivity). Impacts on GHG emissions are also likely to be limited, except for energy efficiency retrofits and (potentially) carbon sequestration (where an important component might be reduced deforestation as well as land restoration). The net GHG impacts of biofuels remains controversial, though there is significant evidence that substitution of crop-based fuels for fossil fuels cause little net drop, and GHGs could well increase for a substantial period from release of stored GHGs in the soil due to cultivation.

For investments in renewable electricity production, the effects will be sensitive to the scale of investment as well as its cost-effectiveness. The near-term stimulus effects are likely to be fairly limited since renewable electricity scale-up takes time. The effect on longer-term economic growth depends on the extent of further cost-reducing advances in renewable technologies.[11] The impacts on other environmental and natural resources would reflect a variety of factors including reduced air pollution, reduced impacts of resource extraction, and reduced deforestation that are scale-dependent. Significant-scale renewable energy investment would have large effects in reducing GHG emissions and, in most cases, fairly to very significant other environmental benefits.

The effects of scaled-up production for new biomass-based energy would be similar to those for electricity, except that the effects on other environmental and natural resources would be sensitive to how the bio-energy is produced. The impacts of investments to improve energy efficiency in new capital also would be similar, though the fact that such investments provide pay-offs from lower energy costs reduces uncertainty about the impacts of long-term growth. Depending on the scale of the savings, we would expect small-to-moderate positive impacts on growth. Green infrastructure investment likewise has this general pattern, except that its high capital cost will limit any long-term positive impact on growth.

Investments in reducing or preventing pollution could have low or medium stimulus effects, depending on the labor intensity of the processes involved. Effects on GHG emissions are mixed, with the prospect of increased emissions in a number of cases due to additional consumption from the pollution control system. Investment in strengthening long-term resilience of natural resources to climate change would tend to have medium-scale stimulus effects (being more labor-intensive in many cases than industrial pollution control), and medium-to-high impacts on long-term growth depending on the vulnerability of the country in question. Some adaptation investments could reduce GHG emissions (e.g. through increased reforestation for land protection), while others could cause an increase (e.g., water storage that results in a substantial period of increased methane emissions from decomposing vegetation).

Our third category of activities in Table 5.1 is something of a catch-all, and includes congestion reduction measures, changes to encourage denser and more mixed-use urban development, the "cash for clunkers" program, and expanded recycling. Many of these activities have their main effects over the longer-term, implying limited short-run stimulus effect ("cash for clunkers" being, perhaps, a counter-example).[12] To the extent that longer-

[11] Fankhauser, Sehlleier and Stern (2008) note that near-term stimulus effects of direct government investment in renewable energy might be larger than for many other investments, because these technologies are not cost effective and thus require more inputs per unit output than alternatives. As renewable technologies mature, this effect would dissipate. See also our discussion of this issue, in Section 6 below.

[12] Most likely, the "cash for clunkers" program has few long-term benefits, as its main impact is to move the phase-out of fuel inefficient vehicles up in time. Its short-run stimulating effects, as well as the "greenness" of

term investments also increase overall productivity, they will also have greater effects on long-term growth. This could be the case for example with increased access to electricity through grid expansion, reduced waste of time due to congestion, and denser mixed-use cities that promote agglomeration economies and more efficient commerce. For different reasons, both expanded recycling (to cut down on health and environmental risks of poor waste management) and congestion reduction (with a co-benefit of increased transportation energy-efficiency) can have significant positive effects on the environment and natural resources. Net impacts on emissions of GHGs are likely to differ. The net impacts of recycling depend on realized reductions in emissions of landfill gases and greater energy efficiency of re-processing materials, as compared to any increased energy consumption in the recycling collection and processing system. The overall environmental and GHG impacts of grid expansion depend, among other things, on the types of energy sources used for power generation.

The table reveals some likely tradeoffs between the effects of alternative policies. First, activities with the greatest potential immediate stimulus effects (in particular, for employment in the short run) often seem to have less favorable growth effects (energy efficiency retrofits and some resilience-increasing activities being possible exceptions). Conversely, a number of activities with strong long-term impacts on growth and welfare are likely to have more limited short-run stimulus effects. Environmental clean-up, natural resource safeguarding, and improving energy efficiency seem to have positive environmental as well as stimulus effects in the short run, as well as environmental effects in the longer run. Considering likely impacts of expanding biofuels production and carbon sequestration, these depend on how such activities are carried out. Better-performing measures with respect to stimulus have in many cases limited or ambiguous GHG reduction impacts. Improved energy efficiency, reduced congestion, and energy-saving changes in urban structure can improve growth, and at the same time reduce GHG reductions. The same should hold for expanding the level of renewable energy production, on condition that the technologies used become more cost-competitive over time.

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the program, also remain to be proven unambiguously; its main effect could have been to serve as a subsidy to new vehicle purchases.

Table 5.1: Major Categories of "Green Stimulus" Policies and Their Anticipated Principal Effects*

Policy category	Type of effect			
	Short-term stimulus	Long-term growth	GHG emission reductions	Environment and resource "co-benefits"
(1) Quickly implemented, labor-intensive, activities				
(a) Non-hazardous environmental cleanup	High	Low/Medium	Low	High
(b) Natural resource maintenance, monitoring and policing	Medium/High	Low	Variable	High
(c) Energy efficiency retrofits	High	Medium	Medium	Medium
(d) Expansion of currently cultivated bio-energy	Medium/High	Low	Variable	Variable
(e) Expanded biological carbon sequestration	Medium	Low	Medium	Variable
(2) Capital investments in environmental and natural resources				
(a) Conventional pollution control/prevention	Low/Medium	Medium	Variable	High
(b) Increased renewable electricity production	Low	Variable	High	Medium/High
(c) Introduction of new forms of bio-energy	Low/Medium	Variable	Medium/High	Variable
(d) Energy efficiency improvements in new capital	Low/Medium	Low/Medium	High	Medium
(e) Green transport infrastructure	Low/Medium	Low	Medium/High	Medium/High
(f) Investment to strengthen resilience of natural resources to climate change	Medium	Medium/High	Variable	High
(3) Other specific programs with "green" characteristics				
(a)"Cash for clunkers"	Medium	Low	Low	Low/Medium
(b) Development and expansion of recycling systems	Low	Low	Low/Medium	Variable
(c) Congestion reduction measures	Low	Medium	High	Medium/High
(d) Altered urban forms for greater density and mixed use	Low	Medium	Medium/High	Low/Medium
(e) power grid expansion	Low	Medium/High	Low/Medium	Variable

*The judgments reflected in the table entries seek to take into account differences in production processes in developed and high-income industrialized countries; for example, bio-energy likely would be more labor-intensive in the former.

What can we say based on Table 5.1 about the desirability of making any particular stimulus package more "green?"[13] The answer to this question depends in large measure on the nature and magnitude of extra "co-benefits" resulting from greater stimulus for green activities. The short-run extra co-benefits comprise largely the internalization of otherwise non-corrected external effects, many of which are environmental, most directly from environmental cleanup activities, and land and biodiversity conservation; but also e g effects such as reduced accident rates and congestion from road traffic when fuel prices are increased.[14] The longer-term economic and environmental co-benefits are potentially even more significant. These will depend on more detailed aspects of the policy environment as well as on the activities themselves. We need to stress that the environmental benefits of pollution cleanup, energy demand stimulus and biodiversity conservation are likely to erode if environmental protection policies are not also at the same time strengthened.

The longer-term benefits of green stimulus are likely to be related to at least two main considerations. The first is the extent to which the investments provide capital services that are more productive and/or less costly than alternatives. For example, if renewable energy is costlier to provide than fossil-fuel energy aside from environmental spillover effects, then the real opportunity cost of energy will rise if green stimulus programs contain large renewable energy components (that would need to be backed up by different forms of regulation to ensure their continued use).

The second consideration, acting as a potential counterweight to the former, is whether the stimulus investment can create enough economies of scale and learning-by-doing effect to bring the production costs for renewable energy or other "green" services and technologies down to levels comparable to those of less green alternatives, gradually over time. Supporting such activity as part of green stimulus will no doubt entail cost-reducing learning-curve effects. Explicitly or implicitly, this factor looms large in a number of green stimulus proposals. Supporting green activity with high learning-curve potential during crisis could then be doubly gainful: such activity is *currently* highly labor-intensive, which can be an advantage today (in particular, when it stimulates employment for worker categories that are currently unemployed); and enhanced activity in the "green" sector may reduce *future* labor costs, which is also advantageous as efficiency and not employment concerns gradually take over as the central goals.

It must again be stressed that the degree of "greenness" is likely to differ among items. As an example, investments in transport and urban infrastructure are likely to be "green" only indirectly as they may permit the development of a less than otherwise energy-intensive society over time. While this effect may be indirect, it could be substantial, a reason being that transportation and urban infrastructure, once laid down, is likely to commit society to particular (high, or low) levels of carbon emissions for very long future periods.[15] Here, obviously, it matters greatly exactly how investments are made. Also, some programs

[13] We are abstracting from the issues raised by Kraay and Serven (2008), who argue that fiscal policy may be relatively ineffective or awkward for crisis stimulus in LICs.

[14] For an extensive discussion of co-benefits of environmental policies, with focus on climate policy, and with application mainly to the OECD countries, see OECD (2009b). An important point made in this study is however that many "secondary" benefits can be secured more efficiently by policies directed more directly at underlying distortions that give rise to the potential co-benefits.

[15] See Shalizi and Lecocq (2009), Strand and Miller (2009), for recent further discussion of such issues.

(including some directed at energy demand) may have short-run environmental effects only, with small or no long-run effects.[16]

As discussed above, economic theory tells us that an efficient policy design requires separate instruments to be applied to achieve separate targets. In practice, however, at least two concerns tend to modify this principle. First, resource re-allocations that are *actually* welfare-improving for all are unattainable as a matter of policy practice.[17] Moreover, best achievable allocations given practical constraints on instrument use are exceedingly difficult to characterize, at least when we wish to do so with high precision.[18] Adding to this problem in a crisis situation is the fact that the economy then is likely to be far away from having an efficient resource allocation, and any movement in the direction of greater efficiency then can be deemed as attractive. The second concern is that the number of practically available instruments is likely to be smaller than the number of targets, and/or not well suited to achieving relevant targets. Such concerns are likely to be particularly serious in developing countries.

In practice, effective instruments that are at one's disposal will need to do more than address just one particular target variable. There is thus at the outset no reason a priori to spurn consideration of the potential for multiple benefits from applying any one given instrument. It is then important to be clear about what sorts of market failures, besides macro-economic under-performance, could give rise to any additional such benefits. Aside from a range of (short- and long-run) environmental concerns, various rationales have included market barriers to energy efficiency on cost grounds; barriers to the introduction of innovative technologies; energy security considerations; and distributional concerns. Each of these rationales needs scrutiny in evaluating the multiple benefits a particular action might engender.

While some measures involve public expenditures. in many sectors most investment will or should be carried out privately, such as in the housing market, in capacity expansion for renewable industries, and sometimes even in transport (toll road construction; bus operation). Efficiency considerations here often favor the private sector, at least in terms of maximizing capital returns (corrected, appropriately, for externalities). A compelling argument here is the discipline created by the market, to strive at higher returns thus minimizing potential inefficiencies. For public investment no such disciplining mechanism exists, at least not automatically. A potential counterweight (that may as a minimum require heavier market intervention) is that private-sector investors typically take a perspective that is overly short-run, facing the need for relatively short-term returns; while this problem is less noted for

[16] The "cash for clunkers" program in the US is probably a case in point. Here the main environmental objective is to induce a rapid exchange of older low-mileage vehicles for new (higher-mileage) ones. Since the required fuel-efficiency improvements for new vehicles are relatively small, and since many of these "clunkers" would in any case be phased out over the next few years, the environmental gain (in the form of emissions reductions beyond those that would otherwise have been achieved) is likely to be small. It seems at least obvious that it would have been a far preferable to induce the same fuel consumption reduction through an increase in the motor fuel tax.

[17] A desirable policy may be *potentially* Pareto improving, in the sense that all individuals could *in principle* be made better off through an appropriate set of transfers between individuals. In practical policy, however, not all such transfers will *actually* be effectuated. As a result some individuals will end up losing, which may be a problem for the political implementability of the policy.

[18] This follows as a corollary to the main theorem of "second best", first stated by Lipsey and Lancaster (1956). This theorem states that, when one condition for first-best optimality is violated, all first-best conditions should in general be violated; with a complex relationship between them. The theorem applies in particular when the number of instruments is short of the number of targets, as discussed below.

public investments. Another consideration is that private investors, in crisis situations, may tend to be overly risk averse and/or credit constrained, thus limiting the practical scope for productive investment in crisis times. Finally, the prevalence of externalities or "spillovers" is important: when such effects dominate, incentives for private investments may be nonexistent (as investors are not able to appropriate a sufficient share of their investments' social returns), and public investment must be used.

6. Potential Quantitative Effects of "Direct Green Stimulus"

6.1 Results for High-Income Countries

Empirical evidence on the macroeconomic and environmental effects of the different categories of green stimulus remains limited. Moreover, it is almost entirely focused on advanced developed countries, with particular emphasis on clean energy investments that are intended to stimulate the economy while contributing to reducing GHGs. Nevertheless, we can attempt to draw some conclusions relevant to developing countries from the available literature. One potential source of information is the literature on benefits of green stimulus programs being advanced by advocates for such programs and for green investment more generally.

To this end, we have examined a number of studies and analyses of clean energy investment, from both high-income countries and from some developing countries. One study of note is released by the Sustainable Energy Finance (SEF) Alliance, a network of organizations collaborating with the UN Environment Programme's Sustainable Energy Finance Initiative (SEFI); and the Global Climate Network (GCN), a group of research centers and other organizations engaged in research and outreach on the economics and politics of greenhouse gas mitigation. While hardly a comprehensive review, the reports by these two wide-ranging groups consolidate a great deal of information related to clean-energy assessment.

Two key observations about the employment impacts of clean energy investment come from a review of this literature. First, *near-term employment stimulus effects are not highly emphasized*. For example, many of the employment projections are for 2020 or 2030. Building up clean energy takes time and there has been a tendency for near-term employment impacts to be overstated (SEF Alliance 2009, pp. 82-83).

Moreover, the reports highlight that potential employment increases over time are the product of several distinct influences. Input-output models show that job creation per unit of environmental expenditure can be significant (Bezdek, Wendling and DiPerna 2008). However, jobs will be lost as well as gained in the near to medium term as the economy adjusts, though there is some evidence that clean-energy investments are more labor intensive than fossil energy investments (GCN 2009b, p. 6). In addition, scarcity of key skill types as the sector grows could slow the economic impacts of clean energy investment. Energy efficiency investments are likely to be an exception, since they have the potential for significant economic returns in the near term and overall social returns sufficient to warrant a substantial level of global investment over the longer term (Anderson 2006).

The other key observation for evaluating projections of employment and other impacts from investments in clean energy is that the *projections generally assume that governments maintain or increase their policy support for such investments*. In part this support can result

from potentially efficiency-enhancing barrier reductions (increased non-discriminatory access to transmission, improved information and clearer economic rewards for energy efficiency), better regulation of conventional pollution from fossil energy, and increased support for innovation. But much the green energy literature also assumes significant future reductions in CO2 emissions in developed countries, and/or posits increased financial support through public venture capital investments, subsidies of private investment, tariff designs, etc. (SEF Alliance 2009, GNC 2009a, 2009b, UNEP 2008a). The applicability and cost effectiveness of such measures in developing countries is open to question.

We turn next to some recent quantitative assessments from model simulations of various "green simulation" measures. One such analysis addresses U.S. measures under the Obama administration stimulus bill (Houser, Nohan and Heilmayr 2009). While not directly applicable to developing countries, the calculations may still be useful as a reference case.

Table 6.1: Impact of US$1 Billion Additional Spending on "Direct Green Stimulus" Activities. Projected for U.S. Under the Obama Economic Stimulus Bill.

"Green" program	Overall employment impact, job years, initial year	Energy cost saving, US$ million annually, 2012-2020	CO_2 emissions reduction, 1000 tons annually 2012-2020	Private share, overall generated, average
Household weatherization	25100	207.8	440.7	0
Federal building retrofits	25300	386.7	546.9	0
Green school construction	25200	609.2	905.8	0
PTC extension	39100	562.5	727.7	76.1
ITC increase	33300	208.7	213.4	47.0
CCS demo projects	28500	225.3	341.6	68.8
"Cash for clunkers"	46900	433.0	1112.5	86.8
Hybrid tax credit	11100	-	-	0
Battery R&D	22500	1278.8	1332.8	0
Mass transit	34500	23.6	87.3	27.4
Smart metering	40000	918.0	207.4	50.0
Average for green stimulus	30100	450	593	-
Road investment	25200	-32.8	-35.4	0

Source: Houser, Nohan and Heilmayr (2009).

The main results, given in Table 6.1, are scaled to show figures for a $1 billion increase in expenditure.[19] The table indicates that the effects on employment, energy consumption and

[19] Note that the table includes some "current spending" items, and some items more naturally categorized as infrastructure investment (including school construction, battery R&D and mass transit). All are consistent with our definition of "direct green stimulus" including government expenditures and provision of incentives for increasing specific activities. Employment effects include all directly and indirectly induced effects.

carbon emissions of additional spending in these programs, per unit of planned expenditure, vary considerably. The ex ante assessed employment effect is greatest for the "cash for clunkers" program. It is also high for continuation of the production tax credit for certain renewable resources including wind, and about average across the options considered for improving building energy efficiency. Other programs are indicated to have significant employment effects per unit of expenditure, but this effect would only materialize over time. Such effects are particularly strong for battery R&D, smart metering, and green school construction (for the two latter, the long-run overall employment effects are in the range three times the short-run effects; and for the former an even greater effect). The programs by themselves (and given that they are not accompanied by e g more general pricing reforms) do not significantly reduce overall U.S. carbon emissions.[20]

One must however be a bit cautious in interpreting the numbers from the Houser et al study, as it is based on a number of potentially contestable assumptions. One is the spending propensity of households of money freed up by lower energy costs, which is assumed in the study to be 50 percent. Another issue is that a good deal of the effects is in terms of "moving up" the employment effect to the current year, which would otherwise occur in later years (as e g for the "cash for clunkers" program). Such aspects of course make the study even more uncertain as a model for similar effects in developing countries.

A few recent studies from high-income countries, all focusing on employment effects of renewable production, may also be of value as a backdrop. Several of these are for European economies where the overall public support to renewable energy has been the greatest. Note that support to renewables production represents a somewhat different category of policies that that just studied for the U.S., in particular as it major effects are more of a long-run character. Renewables support is also typically given a variety of formal justifications apart from net employment or macro output effects (including energy security, reduced carbon emissions, and learning effects and technological development in the energy sector). Even so, at least in many European countries, net job creation has by many been emphasized as a main benefit of support to the renewables sector.

The conclusion of some of these studies is in this respect quite negative. Álvarez et al (2009) discuss employment effects of public support to renewable production in Spain, considering also the lost opportunities to support employment in alternative sectors. The conclusion is that for each job created in the renewables sector, more than two jobs are lost in the rest of the economy. To large measure this conclusion reflects the substantial current difference in energy (in particular, electricity) production costs from renewables, relative to production costs based on other energy sources. This has at least two aspects: first, insofar as direct public support to the renewable sector is concerned, such support is expensive per job created, relative to what can be created in other sectors; secondly, insofar as the support comes in terms of a feed-in tariff structure, electricity prices are raised above rates otherwise experienced, leading to higher business costs with resulting job losses elsewhere. Such losses vary among renewable energy sources, and are particularly high for photo-voltaic solar electricity production. [21]

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[20] The reduction in overall carbon emissions in the U.S. related, say, to a "green stimulus" program of overall size US$ 50 billion would, under these assumptions, amount to about 30 million tons annually, or about half of one percent of current U.S. annual carbon emissions.

[21] The numerical estimates on employment generation from this study have been criticized harshly in the SEF Alliance (2009) study, on a number of accounts. A main objection is that the study is non-specific when

The second study, by CEPOS (2009), considers employment effects of Danish wind energy production. Denmark is today the country with the greatest relative reliance on wind energy in its electricity production mix: with a current share of about 20 percent in terms of potential power generation.[22] This has however come at substantial cost. Over the period 2003-2008, the average direct government subsidy per employed worker per year was in the range US$10000-15000. In addition there is substantial "feed-in" support, via high electricity prices, to Danish wind turbine manufacturers and power producers based on wind. Although no direct net employment figures are offered, the report argues that on net, the funding going to the wind sector could have been more effective in creating employment if going to other sectors.[23]

The two aforementioned studies do not claim to fully capture macroeconomic effects of renewable production and subsidy. A recent and more comprehensive study, by Ragwitz et al (2009), is far more ambitious in this respect. This study attempts to model overall macroeconomic effects of implementing the recently approved European Union plan for scaling-up of renewable production, up to 2030; the effects here include realistic assessments of potential crowding-out of other investments and activities, and disincentive effects of energy price increases as a result of higher energy prices (following e g from feed-in tariff schemes). The conclusion from this study is that there could be noticeable, but not very large, employment effects of this scaling-up, in the short and medium run; as an average for the EU27, employment increases by about 0.15 percent of the labor force by 2010 as well as by 2020. In the longer run employment effects are smaller, which follows from energy cost at that stage passing a threshold beyond which negative further employment effects dominate. GDP effects are here, relatively speaking, more advantageous in the longer run (presumably, as the types of employment that are stimulated by renewable in the long run tend to be high-skilled, with high value added).

In part to illustrate the range of approaches to this basic issue in the literature, we also mention one further study from the US, Kammen et al (2006), with different perspective and conclusions. They consider employment-generating effects over the lifetime of different facilities for production of electricity, based on a variety of energy sources.[24] The finding that they emphasize most is that, given current technologies, solar PV creates close to 10 times the amount of employment (per MW generated) relative to more traditional energy sectors such as coal and gas, and 4-10 times the employment generated by other renewable such as wind and biomass (these, in turn, generate up to 3 times as much employment as traditional sources). This study emphasizes the positive learning effects of current PV production and its positive spillover on future production costs. On the other hand, these results cannot hide the fact that production cost for PV relative to other (renewable or traditional) energies, is currently very high, and that the current value added per worker in the sector is still very low.

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calculating employment effects of renewable production, in terms of jobs foregone in other sectors. While the numerical detail may well be inaccurate, their main qualitative points, that expensive renewable production tends to crowd out other potential (and often more efficient) job creation, is in our view valid.

[22] The report however argues that the share of electricity actually produced from wind power is smaller, only about

[23] It is however also emphasized that, during the 2003-2008 period, there was virtually no unemployment in Denmark and the absorption of labor in the wind sector represented a loss (as this labor would have had higher social returns elsewhere).

[24] See also Fankhauser et al (2009) for further discussion and references.

In reality, the Kammen et al study from the US is not really contradictory to the European studies cited, including the Spanish and Danish studies. Kammen et al focus almost exclusively on job creation due to additional power generation, a limited metric since it does not factor in the opportunity cost of government subsidies for renewable energy. For a given unit cost difference between a renewable energy source and an alternative, the opportunity cost increases with the amount of energy created. Moreover, the greater the cost gap between a renewable energy source and its alternative, the more expensive per unit is the renewable energy production and thus the jobs created per unit of additional renewable energy.

Overall, these studies strongly indicate that government support to producing and developing renewable energies is not a very efficient way of creating additional short-run employment in high-income countries; at least, not when appropriately accounting for the opportunity cost of public funds going into such support. This is perhaps most clear from the Ragwitz et al (2009) study for the entire European Union, which is the deepest and best documented of these studies. This conclusion goes against some officially touted public views; but is in our view not really surprising. The main rationale for public support to renewable energy production in high-income countries is, and must be, its long-run R&D perspective (in addition to a possible "energy security" motivation), with the presumption (or perhaps hope) that unit production costs will come down, perhaps dramatically, over time. Otherwise, such support will remain a perennial drain on fiscal resources, and this public money could, overall, be better spent elsewhere.

As already emphasized, the numbers and analyses presented for high-income countries are not necessarily applicable to most developing countries. In part this is because some of the activities (including significant R&D for new green energy) are outside the scope of what many developing countries are likely to undertake, whatever might be their effects on economic activity in richer countries. For types of projects that are relevant for developing countries, employment effects per unit of spending are in some cases likely to be greater, given lower labor productivity.[25] But in other cases, the direct employment effects per unit of spending could be smaller in developing countries – as when renewable energy projects do not lead to expanded domestic manufacturing but rather to increased imports for the equipment.

One of the most important issues from a developing country perspective is the relative effects compared to impacts of "non-green" infrastructure projects. One category of non-green infrastructure investments likely to *increase* carbon emissions, namely road investments, is included for comparison (in the bottom line of the table). For this project type, the employment effect per dollar spent is less than the average for "green" programs, by about one fifth.[26] Unfortunately, without a more detailed data base it is not possible to make judgments about how the relative performance of these categories might vary in developing countries. However, there are a good number of examples where an expanded and upgraded road system increased employment and output, even if it also raised GHG emissions.

To sum up, the employment effects of different direct green stimulus programs relevant for developing countries vary for two main reasons. First, overall labor productivity may vary; then the employment effect of a given spending will tend to be greatest where labor

[25] This would be the case in which stimulus activities raised productivity as well as contributing to reduced environmental stress.

[26] The difference with respect to energy costs and carbon emissions is of course relatively speaking much greater, since road investment projects tend to *increase* such costs "down the road", as seen from the table.

employment is the lowest. This implies a trade-off: a very high (low) immediate employment effect of given spending is unlikely (more likely) to be very beneficial in the longer run, in terms of spurring technological development and growth, since largely low- (high-) quality labor is stimulated. Secondly, the import content of demand may vary. Domestic employment will then be stimulated most when the import share is the smallest; with a high import share much or most of the stimulus will rather spill over to foreign economies. While having a low import share is unambiguously favorable from a domestic demand management perspective, stimulating demand in sectors with low labor productivity is not unambiguously favorable. Ideally, we wish to allocate any free labor power to activities that yield the highest possible returns; which is often likely to clash with our aim to induce a maximal employment effect.

6.2 Results for Developing Countries

We next examine more specific (but so far, scant and spotty) information on costs of short-run "green" job creation in developing countries. Table 6.2 below provides projected figures for the South Korean green stimulus proposal.[27] The assessed employment effects of this package per US$ billion of spending are similar to those for the US, which may seem surprising as wage levels and labor productivities are lower in South Korea. Note however that the two tables are not fully comparable, as only direct employment effects are counted in Table 6.2, whereas indirect and multiplier effects are counted in the US-based assessment in Table 6.1. The sector that stands out as having the most impact on employment per unit expenditure is, perhaps not surprisingly, forest restoration. We see otherwise that "vehicles and green energy" have relatively poor employment-generating effect, while "energy conservation" and "environmentally friendly living space" generate relatively many jobs per dollar spent.

Table 6.2: Employment Effects of Green Spending Items in South Korea's "Green Stimulus" Package

Spending item	Total Employment Increase	Total Planned Spending (US$ m)	Employment Increase/US$ Bn Added Expenditure
Mass transit	138,000	7,005	19700
Energy conservation	170,000	5,840	29100
Vehicles and clean energy	14,300	1,490	9600
Env friendly living space	10,800	350	30900
River restoration	200,000	10,500	19000
Forest restoration	134,000	1,750	76600
Water resource management	16,000	685	23400
Resource recycling	16,000	675	23700
Green information	3,000	270	11100
Total	703,000	28,600	24600

Source: Barbier (2009).

[27] South Korea is not a typical developing country (it is also an OECD member). We include it here rather than above, as it is a "lower-income" country compared to the others considered above.

Projected employment effects of renewable energy production in China are shown in Table 6.3 below.[28] This table reveals enormous differences in the employment-generating effects of different forms of renewable energy production, from around 7-8 thousand jobs per US$ billion of value added for wind power and solar photo-voltaics, to almost 200,000 jobs per US$ billion for biomass. This reflects great differences in skill levels as well as labor intensities (most jobs in the wind and solar PV sectors are high-skilled, while low-skilled farmers are employed in biomass production), as well as induced effects on imports (much of the equipment used for wind and solar PV is imported). The table however vividly illustrates that the employment effects of renewable energy production in developing countries is likely to vary dramatically across renewable energy sources.

Table 6.3: Employment and Value Added in Chinese Renewable Energy Production. Employment in Numbers of Workers, Output in US$ Million.

Renewable sector	Generation	Manufacturing	Service	Total	Output value, US$ mill	Employment per US$ bn
Wind	6000	15000	1200	22200	3375	6600
Solar PV	2000	38000	15000	55000	6750	8150
Solar thermal		400000	200000	600000	5400	111000
Biomass	1000	15000	250000	266000	1350	197000
Total	9000	468000	466000	943000	16875	55900

Source: Renner, Sweeney and Kubit (2008).

It follows that accounting for the macroeconomic effects of a stimulus package simply by a "number of jobs" created is often highly misleading. Many or most jobs in the wind or solar PV sector are, as noted, likely to be high-skilled; work done in these sectors can contribute substantially also to future technical development and growth (e.g., by "moving down the learning curve"). Most jobs in solar-thermal and biomass production are by contrast lower-skilled, with less scope for technological enhancement and learning effects for the individuals employed.

A recent World Bank study (Schwartz et al 2009) examines implications of fiscal stimulus in Latin American countries. Some calculated effects from this study are given in Table 6.4. Note that employment effects there include *only* workers directly employed by the projects; no attempt has been made to calculate "secondary" effects (of procured deliveries of goods and services) or "tertiary" employment effects (from further rounds such as multiplier effects of generated spending). In that sense the numbers must be interpreted quite differently e g from those in the Houser et al. Study for the US, which accounts for such effects. Still, we find quite sizable employment effects in many cases, notably for projects in the water sector in Honduras; in contrast the Brazilian projects considered give smaller direct employment (this is most so for hydropower projects where the direct employment effect is marginal).[29]

[28] Note that the per-unit employment figures in Table 6.3 are not directly comparable to the figures in Tables 6.1-6.2: the former indicate value added per job; the latter are fiscal costs of creating additional green jobs.

[29] Note that macro effects on employment could also in this case, in principle, be overestimated if the workers engaged in the respective projects have good employment opportunities elsewhere. However, the analysis team assessed such alternative employment opportunities as very small on the whole.

Table 6.4 also gives separate figures for unskilled and skilled labor, as the respective wage shares of total activity generated. Interestingly, for some of the water-sector projects in Honduras the skilled share appears to be quite high (note also that for hydropower projects in Brazil, basically all engaged workers are high-skilled).[30] These numbers indicate that the "growth dimension" of some of these projects may be substantial; although this of course remains to be scrutinized further. Note again that these numbers are very conservative in the sense of only registering employment that is generated directly by the respective projects.

Table 6.4: Direct Employment and Economic Activity Generated by "Green" Stimulus Activities in Latin American Countries. Employment in Man Years per US$ Billion. Activity Generation as Share of Total Activity.

Sector	Direct employment	Share skilled labor	Share unskilled labor	Share domestic inputs	Share foreign inputs
Water capitation, Honduras	43,300	28 %	12 %	40 %	20 %
Water network rehabilitation, Honduras	58,300	30 %	20 %	40 %	10 %
Water network expansion, Honduras	66,700	20 %	30 %	40 %	10 %
Water treatment plant, Honduras	25,000	10 %	10 %	80 %	0
Rain drainage, Brazil	34,000	8 %	16 %	28 %	48 %
Sewerage, Brazil	21,800	4 %	11 %	67 %	17 %
Hydro power, Brazil	4,500	5-10 %		90-95 %	
Rural electrification, Peru	23,000	14 %	7 %	26 %	53 %

Source: Schwartz, Andres and Draboiu (2009).

Which types of "green stimulus" will be most significant for different developing countries requires further investigation, with additional data. The job-creating, and emissions-reducing, effects of such stimulus need to be far more rigorously assessed than has been done to date. One also needs a further analysis of the types of labor engaged by the various projects, by skill category and, ideally, by opportunity cost. Effects are likely to vary widely across countries/regions and among sectors. Most likely, forestry and biodiversity conservation, the water sector, and environmental cleanup (where more remains to be done in many low-income countries), as well as energy efficiency and some renewable energy production (such as biomass for heat and electricity generation) are even more significant "green" activities in developing countries than in high-income countries; some of these also may be relatively good job generators, at least in the short run.

Among other sectors, the employment-creating and revenue-generating effects of expansion of biofuels production and exports could be substantial in some countries, depending on local conditions and the comparative economics of biofuels versus alternatives. Other renewable energy sectors, including wind power and solar photo-voltaics, are likely to be less significant in developing countries over the short-run than in high-income countries, since developing-

[30] Precise definitions of "high" and "low" -skilled labor can vary by country and project; in particular the threshold of what is considered high-skilled could be lower in Honduras than e. g. in Brazil.

countries' plans for expansion of such activities are currently moderate and it takes time to scale up. Moreover, much of the needed basic R&D likely will be carried out in high-income countries.[31] In addition to lag times from in scaling up, stimulus impacts may be limited if, for example, there is no follow-on effect in domestic manufacturing. Over the longer haul, these parts of the renewables sector may be a fruitful avenue for activity expansion in developing countries. As solar and wind technologies further mature, investments in these resources could help some developing countries improve their competitive position relative to high-income countries in the global economy.

7. Discussion and Final Comments

Barbier (2009) assesses potential job-creating effects of green stimulus. Three areas are, in his view, central for the combined task of job creation and promoting conservation and carbon emissions reductions: (a) improving energy efficiency and conservation; (b) expanding "clean energy" supply options; and (c) improving the sustainability of transport. The direct evidence of employment-generating effects from such policies is however scant, reflecting the dearth of relevant applicable individual-country data in the current literature. Those activities that involve larger capital investments (for example, biomass processing facilities and domestic biofuel production facilities as well as some transport initiatives) will bear most of their fruit over the longer term and thus are much less likely to provide strong short-term stimulus than other alternatives.

In terms of overall activity generation with a long-term perspective rather than short-term stimulus, infrastructure investment is likely to be an especially important expenditure category. The recently issued Infrastructure Diagnostic Tools paper (World Bank 2009a; particularly Annex 2) emphasizes transport, energy supply, water and the urban sector as the most relevant sectors for infrastructure investments with that can provide positive economy-wide impacts over time as the projects are realized, and that can potentially include "green" components. Still, the "greenness" of available investment categories varies considerably. No less important in our context is that much investment categorized as "green" is relatively large and with long time horizons, providing value in terms of attaining long-term goals but less useful for short-term stimulus. Within the transport sector, for example, the "greenest" infrastructure investments would be those that substitute out the most energy demanding transport modes, notably motorized private road transport. But infrastructure projects here are heavier and/or longer-term (such as rail or broad-based BRT), and thus less suited to be short-run measures. Within activities such as water supply and electric power transmission there could be somewhat better opportunities for win-win situations related to short-run public expenditure, through upgrading and improvement of existing infrastructure, to improve efficiency of delivery.

Focusing on the energy sector, many projects to develop and support renewable energy sources on a large scale would have similar characteristics, as would projects to replace coal with less carbon intensive fuels, or to improve the thermal efficiency of coal burning (in power plants, factories etc.) Among projects with more immediate-term impacts are energy efficiency measures in buildings (weather-proofing), and in agriculture, which could yield significant cost savings and also be relatively labor intensive. The same could apply to upgrading of power transmissions systems which allow for reduced losses of given power

[31] Notable exceptions here are China for wind power, and India for solar photo-voltaics; both are aiming to soon become world leaders in their respective fields.

generated. Small-scale investments in off-grid renewables could also have positive near-term impacts, but their scale is likely to be small relative to the overall stimulus requirements under discussion.

For water infrastructure, most relevant investments likewise are relatively large, with long planning horizons and lifetimes, and thus probably less effective for short-term stimulus – though some near-term benefits certainly are realized by starting up projects that are actually "shovel-ready." However, the longer-term issue here, related to major investment projects, is the extent to which the execution of such projects leads to more overall efficient allocation of given water resources. In the water sector there are, in many developing countries, a large potential for improving the efficiency of given water infrastructure, in terms of reducing leaks and the degree of illicit water extraction. Such improvements can be made by simply upgrading existing infrastructure, which is typically labor-intensive, and this can be done at relatively short notice.[32]

For the urban sector and urban investment, the "greenness" concept is a more complex one. One factor is more concentrated urbanization, which may lead to less urban sprawl, resulting and thereby less energy use and carbon emissions relative to services rendered.[33] Increased urbanization in developing countries may also have substantial "green" aspects by taking population pressure off forested areas with threatened deforestation. However, such demographic changes will have only limited impacts in the near term (e.g. if urban investments slow down reverse migration of unemployed).

This discussion suggests that the scope for short-run "direct green stimulus" through increased investments in developing countries could be relatively small. This is because most such investment is lumpy and takes time to plan and implement, and a hurried application can be counterproductive as it may turn out to not fully meet each country's required needs. Stimulus through current expenditures which do not directly add to infrastructure may then look more promising. However, significant additional research is needed to better address these questions quantitatively.

Central to our discussion in this paper is our classification of stimulus measures in Table 5.1, and the assessed (short- and long-run) effects of these measures. Overall, this table reveals few obvious candidates for triple-win policies, with simultaneous strong benefits for short-term economic recovery, longer-term growth, and long-term environmental benefits. Certain labor-intensive renewable energy investments could, in principle, have strong stimulus benefits in the short term and, if economically sustainable, long-term benefits due to reduced GHG emissions and improved growth. Certain infrastructure projects could be beneficial to long-term growth and emission reduction, but their short-term stimulus benefits are probably limited.

In the context of clean energy investment, there is a need to increase R&D funding to enhance the economic competitiveness of large-scale renewable investments. However, as we noted at

[32] In many cities in Latin America, Africa and Asia, more than 50 percent of potential water supply is lost to leaking pipes, which can be repaired or replaced. In many cases greater efforts to control how water is allocated, may in themselves bring improvements. For example, illicit water extraction and reselling from tank trucks is in some cases a problem, whose elimination may bring several improvements both in efficiency and in terms of reduced energy consumption.

[33] Glaeser and Kahn (2008) show that per-capita carbon emissions are dramatically lower for relatively compact urban regions in the US, such as the New York metropolitan area, when compared to metropolitan regions that are more decentralized, such as Atlanta or Houston; and even more so when compared to rural regions.

the start of this paper, "green" development in the long run is difficult to achieve without micro units (households and businesses) facing appropriate price signals. This implies the need for including, as part of effective long-term "green growth" policies, the removal of subsidies and other distortions (in particular for energy consumption) that lead to inefficiently low levels of market-motivated "green" investment. While many of the relevant distortions are politically motivated and thus difficult to remove, there are nonetheless several reasons why such changes in pricing policies need to be advanced.

While direct stimulus through increased spending may have higher near-term economic benefits in times of crisis (through additional employment and activity thereby generated), it is, under such circumstances, also likely to face higher financing costs than in more normal times. While wage rates and prices of some commodities may be lower in crisis times, fiscal budgets will be far tighter, and credit more expensive and more difficult to obtain.[34] Moreover, the drop in energy prices during a crisis may ease the political constraints on governments' ability to implement a desired phase-out of energy subsidies.

In addition, long-run economic and environmental effects of removal of pricing distortions are likely to be far stronger than the effects of increases in direct government expenditures. The main reason is that the former provide increased incentives for long-term investment, thereby also increasing the efficiency of the long-term resource allocation. Pricing reforms can complement targeted direct investments to remove bottlenecks in the economy. Investments without pricing reforms face greater inertia by not embedding similar types of incentives.

Perhaps most importantly, an economy in crisis faces difficult tradeoffs. Decisions to set priorities must be made to allocate spending, in types and amounts, in a time of diminished resources and constraints on the ability to increase debt. As a result, the need to create additional "fiscal space" by raising additional public revenue without unduly distorting the economy also attains a higher priority – especially if there are also plans for significant direct stimulus.[35] Since the fiscal balance is typically worsened by such spending, the long-term growth prospects are more uncertain as the government's future fiscal space is diminished.[36]

In contrast, to the extent that fiscal measures that serve to correct energy-related price distortions also serve to increase government net revenue, such revenue can be used to help finance short-term stimulus and longer-term investment in green public-sector infrastructure with less of a long-term public debt burden. When indirect stimulus targets in particular the removal of environmentally harmful subsidies or under-taxation, the policies can also have substantial environmental- and climate-related "co-benefits". For these reasons, as well as those cited above, the current crisis provides an especially important occasion for addressing persistent distortions in market prices or under-taxation of energy and other natural resources.

Some recent studies have attempted to quantify the magnitudes of direct and indirect subsidies in the environmental and natural resources sectors.[37] It will be important to improve such quantification, including also the revenue losses from under-capture of resource rents for

[34] Indeed, at least in part as a consequence of the countercyclical cost and availability of funds and credit to governments, fiscal policy in many LICs tends to be not countercyclical but rather procyclical, as discussed by Kraay and Servén (2008).
[35] See also IMF discussions of similar issues e g in Heller (2005).
[36] See Servén and Kraay (2008) for a discussion of general principles of fiscal policy to meet the current crisis; their strong advice is that fiscal expansions be sustainably financed.
[37] See for example IEA (2008). UNEP (2008b) also addresses energy subsidies.

publicly managed resources; the employment and other economic effects of increased fiscal space through price reforms; and the practical feasibility of overcoming political economy barriers to the reforms.

Conversely, there is need for more research on the implications of direct green stimulus for long-run fiscal sustainability. Here one big question is whether direct green stimulus provides better or worse ability of the economy to recuperate public revenue down the road. This must be based on an analysis of sectors, activities and groups most benefitting from a green stimulus effort, with comparison as well to economy-wide measures to enhance fiscal sustainability.

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