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'Green' Growth, 'Green' Jobs and Labor Markets

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Abstract

The term 'green jobs' can refer to employment in a narrowly defined set of industries providing environmental services. But it is more useful for the policy-maker to focus on the broader issue of the employment consequences of policies to correct environmental externalities such as anthropogenic climate change. Most of the literature focuses on direct employment created, with more cursory treatment of indirect and induced job creation, especially that arising from macroeconomic effects of policies. The potential adverse impacts of green growth policies on labor productivity and the costs of employment tend to be overlooked. More attention also needs to be paid in this literature to how labor markets work in different types of economy. There may be wedges between the shadow wage and the actual wage, particularly in developing countries with segmented labor markets and after adverse aggregate demand shocks, warranting a bigger and longer-lasting boost to green projects with high labor content. In these circumstances, the transition to green growth and job creation can go hand in hand. But there are challenges, especially for countries that have built their industrial development strategies around cheap carbon-based energy. Induced structural change, green or otherwise, should be accompanied by active labor market policies.

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‘Green’ growth, ‘green’ jobs and labor markets

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1. Introduction

The challenge of human-induced climate change has led to renewed interest in sustainable growth as a means to promote human development. Growth – of the right type – remains an effective way of lifting people out of poverty (see, for example, Collier, 2007). Growth of the wrong type will eventually be self-defeating, as environmental degradation reduces productivity and welfare. The OECD has noted that "green growth is gaining support as a way to pursue economic growth and development, while preventing environmental degradation, biodiversity loss and unsustainable natural resource use" (OECD, 2010). There is particular concern about the consequences of human-induced climate change. As the World Bank's World Development Report 2010 argues, "Economic growth alone is unlikely to be fast or equitable enough to counter threats from climate change, particularly if it remains carbon intensive and accelerates global warming. So climate policy cannot be framed as a choice between growth and climate change. In fact, climate-smart policies are those that enhance development, reduce vulnerability, and finance the transition to low-carbon growth paths" (World Bank, 2009). Stern (2010) thinks that "the new industrial revolution and the transition to low-carbon growth constitute a very attractive path. It is likely to bring two or three decades of innovative and creative growth and large and growing markets for the pioneers. Low-carbon growth, when achieved, will be more energy-secure, cleaner, safer and more bio-diverse than its predecessors."

But what are the consequences of 'green' growth for labor markets? UNEP (2011) has argued that "the greening of economies is not generally a drag on growth but rather a new engine of growth; that it is a net generator of decent jobs, and that it is also a vital strategy for the elimination of persistent poverty." The recent global economic downturn triggered many proposals for 'green' fiscal stimuli to promote growth and, in particular, jobs (see, for example, Pollin et al., 2008). The OECD has also suggested that investing in green activities has significant job creation potential (OECD, 2011).

Yet some have claimed that the potential is overestimated and environmental policies may have much less attractive labor market consequences (e.g. Morriss et al., 2009). Michaels and Murphy (2009) argue that "it is highly questionable whether a government campaign to spur 'green jobs' would have net economic benefits." Hughes (2011) has written about the 'myth' of green jobs, arguing additionally that job creation has no merit as a basis for judging

policy. Policies to promote 'green' jobs have even been alleged to be "terribly economically counterproductive" (Alvarez et al., 2010).

This paper explores the possible relationship between labor markets and policies to promote sustainable growth – improving well-being with societies taking proper account of resource depletion and environmental impacts. In Section 2, the concept of 'green' jobs is discussed. In Section 3, some of the empirical estimates of job creation are reviewed, concentrating on the issue of how labor markets are assumed to function. Most of the literature is focused on developed industrial economies, but there have been attempts to estimate some of the employment consequences for developing countries. However, it is not clear that these make appropriate allowance for the range of ways in which labor markets function, an issue discussed in Section 4. Section 5 draws attention to the heterogeneity of developing countries with respect to the opportunities for job creation in green growth. In Section 6, the question of the skills necessary to support green growth is considered. Finally, some of the possible implications for policy design in developing countries, and for research priorities, are considered.

2. The concept: What are 'green' jobs?

There is no single agreed definition of a 'green' job. That makes it hard to compare studies of 'green' job creation (GHK, 2009) and has led some researchers to eschew use of the term completely. In a loose sense, though, 'green' jobs can be regarded as those associated with environmental objectives and policies.

Some definitions of 'green' jobs or related concepts focus on occupations and skills with an identifiable environmental focus, but most focus on employment in industries (or specific projects) the products of which are deemed to be of environmental benefit. Such benefits can be defined more or less broadly – for example, some concentrate on renewable energy, including or excluding biofuels, while others also include environmental services and/or employment related to improving energy efficiency or developing less-carbon-intensive products (e.g. building railways).

UNEP has adopted a definition that attempts to incorporate aspects of job content as well as the characteristics of industry gods and services (UNEP/ILO/IOE/ITUC, 2008). It defines 'green' jobs as "work in agricultural, manufacturing, research and development (R&D), administrative, and service activities that contribute substantially to preserving or restoring environmental quality. Specifically, but not exclusively, this includes jobs that help to protect ecosystems and biodiversity; reduce energy, materials, and water consumption through high-efficiency strategies; de-carbonize the economy; and minimize or altogether avoid generation of all forms of waste and pollution." This definition takes a broad industry perspective, extending beyond employment in narrowly defined environmental services. In principle, it embraces employment in producing any goods and services that have smaller adverse environmental impacts than existing close substitutes. UNEP also argues that there is a spectrum of 'greenness': "There are different degrees to which technologies, products, businesses, and business practices can be said to be green, ranging from reactive and remedial measures on the one hand to proactive measures on the other." In other words, cleaning up pollution after the event is less green than stopping the pollution in the first place. That appears to beg the question as to the most efficient way of dealing with an environmental problem and would lead to the classification of many environmental services as less green than, say, employment in the packaging industry.

However, UNEP adds the rider that "green jobs need to be decent work, i.e. good jobs which offer adequate wages, safe working conditions, job security, reasonable career prospects, and worker rights. People's livelihoods and sense of dignity are bound up tightly with their jobs. A job that is exploitative, harmful, fails to pay a living wage, and thus condemns workers to a life of poverty can hardly be hailed as green." UNEP suggest that, at a conservative estimate, there were more than 2.3 million jobs in the renewable energy sector around the world in 2006, and more in construction, providing improved energy efficiency in buildings, in low-carbon transport and in other environmental activities. But that compares with an employed labor force globally of around 1.8 billion.

Thus the UNEP definition also extends to characteristics of the jobs themselves. However, their definition conflates different social objectives in one term. The rider is particularly problematic in developing countries where more employment may be desirable for the relief

of poverty and an increase in overall productivity – even if the jobs created pay little more than a subsistence wage or the employment is in less green industries and skill classes.

Some definitions focus on a subset of industries producing environmentally desirable outputs. Thus some studies, notably by the European Commission's Environment Directorate, have used the OECD/Eurostat definition of the environmental goods and services industry (OECD, 1999), comprising "activities which produce goods and services to measure, prevent, limit, minimize or correct environmental damage to water, air and soil, as well as problems related to waste, noise and eco-systems. This includes technologies, products and services that reduce environmental risk and minimize pollution and resources." That covers pollution management (e.g. air pollution control) and resource management (renewable energy plants and water supply). On this basis, green jobs constitute a small but significant share of total employment – 1.7% of total paid employment in Europe (EC, 2007). That is probably a higher fraction than a global estimate along UNEP lines would suggest; as UNEP notes, most of the documented growth in green jobs has so far occurred mostly in developed countries.[1] Jobs in the nuclear power sector are not included, and these are not generally regarded as 'green', although they are in a low-carbon industry. Employees in many jobs might find that their jobs are not counted as 'green' despite the nature of the goods and services that they help produce. For example, jobs in the car industry are excluded, even though some may be devoted to developing low-carbon vehicles.

Some studies have developed their own terminology, using data from detailed employment statistics or detailed company databases. The Pew Center, for example, defines the 'clean energy economy' as follows: "The 'clean energy economy' generates jobs, businesses and investments while expanding clean energy production, increasing energy efficiency, reducing greenhouse gas emissions, waste and pollution, and conserving water and other natural resources" (Pew, 2009). It comprises five categories: Clean Energy; Energy Efficiency; Environmentally Friendly Production; Conservation and Pollution Mitigation; and Training and Support. Using data about individual companies, Pew estimates the USA's 'clean energy economy' to account for about half a percent of all US jobs.

[1] At the same time, developed countries are responsible for by far the largest share of the stock of greenhouse gases in the atmosphere. They have also probably made a disproportionate contribution to long-lived solid waste. Hence some of the green jobs reflect the unsustainability of developed countries' economies.

Some definitions start from a different analytical perspective and try to answer the question: "What are the employment consequences of introducing 'green' policies (e.g. 'cap and trade') relative to a baseline case?" This approach requires implicit or explicit economic modeling of the policies. Some studies in this vein count only jobs directly created by the policies ('direct' employment effects) while others include jobs created in the supply chain for the products and services supported by 'green' policies ('indirect' employment effects).

Kammen at al. (2004) and Wei et al. (2010) review several studies that estimate direct employment effects of promoting renewable and other low-carbon energy supply and energy efficiency, focusing on the specific labor requirements of particular technologies ('bottom up' estimates, using simple spreadsheet-based analytical models in conjunction with engineering estimates). An important issue that arises is the timing and duration of job creation; there is a key distinction between construction, manufacture and installation, where jobs may be relatively short-lived, on the one hand and ongoing operation, maintenance and fuel processing on the other, where the length of jobs depends on the durability of the relevant plant.

They also consider studies that use input-output (I-O) tables to estimate both direct and indirect employment effects, taking account, for example, of the jobs created in business services provided to the renewable energy sector. These extend the scope of the estimates while sacrificing the greater granularity derived from engineering studies of specific energy projects. I-O based studies also fall prey to the usual criticisms of input-output models: that they do not allow for changes in input-output coefficients induced for example by relative price changes and technological progress; that they are often out-of-date; that they depend on industrial classifications that do not distinguish some of the key sectors of interest; and that they are highly aggregated. The meta-studies by Kammen and his associates attempt to derive standardized measures to compare estimates of jobs created per average megawatt over the life of an energy facility. The authors also explore the implications of various scenarios of exogenous energy efficiency improvements and renewable energy portfolio standards for US employment in total. As they take into account jobs destroyed when fossil-fuel-based energy is displaced by low-carbon sources, their projections are for a net concept of employment change, but they do not take into account general equilibrium effects through relative wage changes.

Others go further still and include jobs created by the aggregate demand generated by the extra direct and indirect employment ('induced' employment effects). This approach allows jobs to be counted as 'green' if they are created by 'green' policies, even if they are in sectors with no obvious direct relationship to environmental objectives (e.g. tobacco processing) or only a secondary relationship (e.g. construction). A question arises as to whether one should net off jobs destroyed in sectors disadvantaged by 'green' policies (e.g. coal mining). This issue is less relevant if one is simply trying to enumerate jobs associated directly with environmentally attractive goods and services. But it is crucial if one is trying to evaluate the overall labor market impacts of environmental policies. Some studies finesse this issue by focusing on the job creation implications of different fiscal stimulus packages with greater or lesser reliance on 'green' spending, none of which are expected to destroy jobs. Pollin et al. (2008) is a good example of this type of study, utilizing an estimate of the macroeconomic multiplier effect of additional direct fiscal spending to calculate induced employment creation. It has stimulated a lively debate about the merits of trying to create 'green' jobs by means of a fiscal stimulus (see Box 1).

Box 1: Myths or reality of green jobs?

This Box summarizes the debate between Morriss et al. (2009) and Pollin (2009) about green jobs and comments on the implications for analysis in the context of developing countries.

The supposed myth	The riposte	Comment
Everyone understands what a 'green job' is	One should focus on the green economy and overall employment effects, not 'green' jobs	It might be helpful if the green transition in developing countries creates unskilled jobs, given the extent of underemployment
Creating green jobs will boost productive employment	Properly designed spending should stimulate the production of useful goods and services, not Keynesian 'make-work'	Low carbon growth strategies for developing countries should emphasize the potential for the supply of clean energy – jobs in this sector would be productive but, given low wage rates, jobs are quite properly likely to be low productivity ones
Green jobs forecasts are reliable	All forecasting is subject to uncertainty; the linear input-output approach is helpful as long as the methodological	More emphasis needs to be put on the macroeconomic and general equilibrium adjustments and job

	caveats are recognized	displacement; modeling for the US labor market at a time of high unemployment may not be very instructive for developing countries
Green jobs promote employment growth	Clean energy is more labor intensive than fossil-fuel industry; low productivity jobs are better than zero productivity unemployment; the low-carbon transition will create higher paid jobs too	There is more scope for employment creation in developing counties given their segmented labor markets and low productivity; but low-carbon jobs may be low-wage jobs
The world economy can be remade by reducing trade and relying on local production and reduced consumption without dramatically decreasing our standard of living	The low-carbon transition would increase local content; trade patterns would change; the USA is running too big a trade deficit	This is problematic for emerging-market economies that wish to export to the USA; more analysis is required of how world trade patterns would change (e.g. if biofuels displaced fossil fuels)
Government mandates are a substitute for free markets	Pricing an externality requires public policy intervention; but policies should work with market incentives	High-quality collective decision-making and intervention in markets are challenges for many poorer countries
Imposing technological progress by regulation is desirable	Many of the necessary changes in production can be carried out with existing technologies; some support for renewable energy R&D is warranted	Innovation can be stimulated by market-based incentives; more support is needed for research into low-carbon energy and other products particularly suitable for developing countries given their level of development and endowments

Another approach considers different time horizons; the further away the time horizon, the more economic variables can be adjusted. Fankhauser et al. (2008) consider

- *A short-term effect*, when jobs are lost in sectors directly adversely affected by new climate change policies and new ones are created in replacement industries. This they label the direct employment effect.
- *A medium-term effect*, when the impact of climate change policies diffuses throughout the economy, creating and destroying jobs along the value chains of affected industries.

These they call the higher-order, economy-wide effects of climate policy. That corresponds to indirect and at least some induced effects.

- *A long-term effect*, when innovation and the development of new technologies create opportunities for investment and growth. This they call the dynamic effect of climate policy, a benign induced effect that has had less attention in the literature. But learning by doing usually helps to increase labor productivity, so the impact on jobs of introducing a new technology may be attenuated over time.

Ho et al. (2008) take a similar approach in their study of the impact of carbon price policies on US industry, considering outcomes along four different time scales:

- The very short run, where firms cannot adjust prices and profits fall accordingly.
- The short run where firms can raise prices to reflect the higher energy costs, with a corresponding decline in sales as a result of product or import substitution.
- The medium run, when in addition to the changes in output prices, the mix of inputs may also change, but capital remains in place, and economy-wide effects are considered.
- The long run, when capital may be reallocated and replaced with more energy-efficient technologies.

They found that, over the short term, employment losses were likely to mirror output declines, but, in the longer term, gains in other industries would fully offset those losses.

Finally, some studies attempt to take more thorough account of economy-wide ramifications of 'green' policies such as carbon pricing by using some form of general equilibrium modeling. This is implicit in estimates of induced employment, because some macroeconomic theory is needed to determine what happens to aggregate demand. The multiplier-based approach exemplified by Pollin et al. can be thought of as being based on a simple fixed-price Keynesian view of the macro-economy with Keynesian unemployment and some 'leakage' of injections of aggregate demand to exports from other countries.

Computable general equilibrium models in the neoclassical tradition paint a very different picture. They usually assume complete markets and instantaneous Walrasian price adjustment, so that there is no involuntary unemployment. In such models, implementing carbon pricing will both tend to redistribute labor to low-carbon activities and reduce overall

labor supply, because the higher relative price of carbon-intensive goods and services reduces the real wage of labor, thus encouraging households to work less. They recognize that employment costs are generally a social cost, not a social benefit, an important point often missing in green jobs studies. According to this framework, there can be net job destruction, depending on how the revenues from carbon pricing are used. In the study by Goettle and Fawcett (2009) of the potential implications of a cap-and-trade system for the USA, for example, there are significant reductions in labor input in 29 out of 35 US industries (if there is no revenue recycling). Box 2 gives an informal analysis of the importance of economy-wide effects in a simple neoclassical setting.

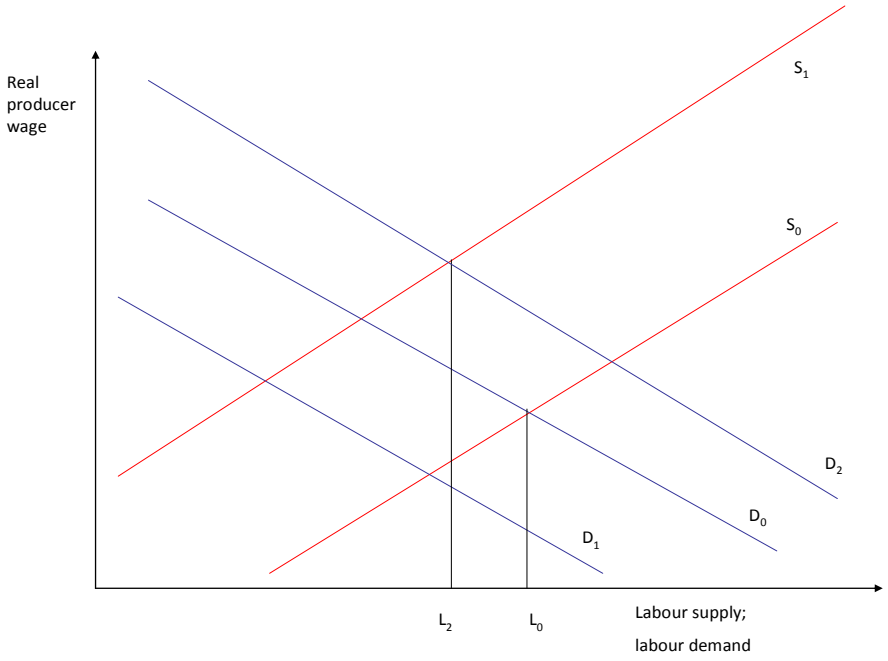
Hence knowing how best to model how the aggregate labor market works – and, indeed, how the macro-economy as a whole works – is crucial for a proper assessment of changes in direct and indirect labor demand, and first-round and induced employment effects. There are important differences across types of economy due to different industry structures, labor market institutions and endowments. Probably the most useful concepts to which to attach the label of green jobs are the gross and net numbers of jobs created as a result of green policy implementation. In the case of climate change policies, it would be appropriate to consider the net and gross labor market impacts not only of carbon pricing but also of other efforts to correct market failures contributing to carbon emissions, such as market failures afflicting innovation and the provision of energy infrastructure.

The importance of the implicit or explicit macroeconomic framework is illustrated by Babiker and Eckaus (2007), who show how, in the presence of real wage rigidities or barriers to the sectoral reallocation of labor, climate policy could increase unemployment. Overall labor market impacts can also be influenced by how the revenues from carbon pricing or quota auctions (or other environmental taxes) are used, as illustrated by the literature on the so-called 'double dividend' from environmental taxation (see, for example, Fullerton and Metcalf (1997) and Sartzetakis and Tsigaris (2007)). Studies tend to show that if tax revenues are used to reduce payroll tax – a tax on labor supply – employment will fall by less or even increase.[2]

[2] But they rarely ask why the tax authorities have been levying a payroll tax in the first place. It may be a second-best way of raising tax revenue and still have a place in the second-best menu of taxes.

Box 2: Different measures of job creation – A diagrammatic illustration

Consider a simple textbook neoclassical economy. Aggregate labor demand is a declining function of the real producer wage. Aggregate labor supply is an increasing function of the real consumption wage. When carbon pricing is introduced, this introduces a wedge between the producer wage and the consumption wage because the carbon content of consumer goods is taxed. In the figure below, aggregate labor supply shifts from S_0 to S_1.



The introduction also reduces the profitability of production of carbon-intensive goods for a given real producer wage, using currently deployed technologies. That will tend to reduce aggregate supply at any given product wage. Aggregate labor demand shifts from D_0 to D_1. But it also makes it profitable for some companies to switch to low-carbon technologies, which empirically appear to be more labor-intensive but less-capital intensive than their predecessors. Over time, as new low-carbon plant and equipment are installed, the aggregate labor demand schedule therefore shifts out again. In the figure, the schedule moves out over time to D_2, which is drawn to the right of D_0. This shift can be thought of as the increase in labor demand as a result of the change to low-carbon technologies at constant (zero) pure profits, which is analogous to some of the estimates of green job creation in the literature (but is likely to be less than the green jobs created holding output constant, as one would expect some substitution away from the previously carbon-intensive goods and services). Public spending on capital for low-carbon production could accelerate

the shift. But the shift from D_1 to D_2 may not be large enough to push aggregate labor demand at any given product wage above its original level given by D_0. That will depend on:

- how labor intensive the new technologies are compared with the old;
- how profitable the new technologies are at the chosen level of carbon pricing, which itself depends on the importance of learning-by-doing and other forms of induced technological progress;
- what is done with the revenues from the carbon pricing; recycling of tax revenues to households will increase aggregate product demand (and a reduction in payroll taxes could shift aggregate labor supply back towards S_0).

Even when D_2 is to the right of D_0, the net effect on employment of the introduction of the carbon tax is a reduction in employment from L_0 to L_2. The horizontal shift from D_0 to D_2 is an over-estimate of the job creation induced by the introduction of carbon pricing. Thus this measure of green job creation is misleading about the macroeconomic effects of climate policies, because it neglects jobs lost from the initial leftward shifts in both the labor demand and labor supply schedules.

If the labor supply schedule S is vertical, the shifts in the aggregate labor demand schedule induced by carbon pricing affect only the equilibrium real product and consumption wages, not total employment. Net green job creation is zero regardless of the relative labor intensity of high- and low-carbon technologies.

This informal analysis serves to illustrate the importance of knowing how the labor market works at a macroeconomic level in order to work out the employment effects of climate policies. Estimates of gross job formation from switching from high- to low-carbon technologies can be very misleading, especially if it is assumed that output of the originally carbon-intensive industry remains unchanged.

However, the simple neoclassical textbook case is usually not the most appropriate way of modeling the aggregate labor market despite its utility in providing a benchmark. Other assumptions are possible. For example, nominal wage or price rigidities may make the effective aggregate labor supply curve horizontal while leaving some workers involuntarily unemployed – the neo-Keynesian framework. Then questions arise as to whether carbon pricing is or is not passed through to final goods prices and whether and how nominal wages

respond. Carbon pricing could in this world act initially like an adverse aggregate supply shock creating involuntary unemployment (ruled out by assumption in the neoclassical case above). But there would also be a case for Keynesian deficit-financed spending, including on low-carbon plant and equipment, to increase employment.

3. Empirics: Estimates of potential 'green' job creation

A number of surveys have collated estimates of 'job creation potential' in green activities variously defined and discussed their methodological strengths and weaknesses, including GHK (2009), Fankhauser et al. (2008), GCN (2010) and the World Bank (undated). Kammen at al. (2004), Wei et al. (2010), and the World Bank (undated) have reviewed the literature on employment creation in the energy sector, including jobs in renewable energy. The estimates covered use a range of methods, reflecting the different definitions of green job creation discussed above. As GHK (2009) notes, "The estimates are not comparable due to:

- Geographical differences – EU, US, Member State, global;
- Sectoral differences – often focusing solely on individual sectors or sub-sectors;
- Gross and net effects;
- Inclusion / exclusion of whole value chain effects; and
- Differing assumptions concerning economic growth and the effect of existing business as usual policies."

GHK tabulate results from 32 different studies; most used data from the EU or specific member states, seven used US data and four global data. No studies explicitly covered developing countries per se. Wei et al. (2010) cover 15 different studies, only one of which explicitly mentioned a developing country (Brazil). The World Bank review of energy and employment tabulates results from 33 studies, of which five focused on some aspect of energy in developing countries. Five out of the 15 studies covered by Wei et al, 14 out of the 32 studies covered by GHK and 25 out of the 33 studies covered by the World Bank are dated 2008 or later.

Given the heterogeneity of the studies, it is very difficult to draw broad conclusions. The impression given by many of the findings is that climate-change policies in general and renewable energy in particular can generate considerable extra employment. But many

studies ignored the potential for job destruction in non-green industries or implicitly or explicitly assumed that there would be no crowding out of jobs via general equilibrium effects. Most studies did not take into consideration general equilibrium effects at all while some others offered a qualitative discussion. Few of the studies considered labor market problems such as sector-specific human capital and job search costs that could slow the shift of workers across sectors or out of long—term structural unemployment. Several of the studies were in fact designed to assess the job creation possibilities from green policies at a time of widespread involuntary unemployment – hardly surprising considering the severity of the global downturn that has recently been experienced but not necessarily indicative of green job prospects in moving from one longer-term growth path to another. However, arguments might equally be advanced for many other employment generation policies.

Wei et al. (2010) are illustrative of the general thrust of the literature when they write: "Our modelling approach yields the following key conclusions:

- The renewable energy and low carbon sectors generate more jobs per unit of energy delivered than the fossil fuel-based sector.
- Among the common RPS [renewable portfolio standard] technologies, solar photovoltaics (PV) creates the most jobs per unit of electricity output.
- Energy efficiency and renewable energy can contribute to much lower CO_2 emissions and significant job creation. Cutting the annual rate of increase in electricity generation in half and targeting a 30% RPS in 2030 each generates about 2 million job-years through 2030 [in the USA].
- A combination of renewable energy, EE [energy efficiency], and low carbon approaches such as nuclear and CCS can yield over 4 million job-years through 2030 [in the USA] with over 50% of the electricity supply from non-fossil supply sources."

Pollin et al. (2008) similarly argue that a $100 billion fiscal stimulus in the USA spent on six energy efficiency and renewable energy strategies would generate two million jobs. The inclusion of indirect and induced employment means that many of the jobs created are not in the conventionally defined 'green' industries (see above). Indeed, non-direct employment creation is often larger than direct job creation given the assumptions about supply chains and fiscal multipliers, reassuring authors that direct job losses due to the contraction of fossil-fuel-intensive activities can be outweighed by the total gross job creation. Renewables are more labor-intensive than conventional energy, especially at the construction,

manufacturing and installation stage (less so in operation and maintenance, partly because fuel input management is not necessary).

Fankhauser et al. (2008) note two important caveats. First, higher labor intensity per unit of energy capacity created implies lower labor productivity than in conventional energy production. Renewable energy may be more expensive and less efficient than conventional sources, with high capital as well as labor requirements, shorter-lived plant and more intermittent energy production. Thus some studies of potential employment creation ignore the question of whether it would be profitable for the private sector to adopt the programs considered. Second, labor is relatively immobile in the short run, so policy changes may create transitional frictional unemployment due to the structural change induced. Both points reflect the tendency for employment creation studies to be vague about the macroeconomic adjustment mechanisms implicit in their estimates.

In addition to those two caveats, studies rarely take into account the macroeconomic consequences of higher real energy prices (or higher energy subsidies) on the overall price level, labor supply, labor productivity and taxation. Converting countries' energy sectors to low-carbon technologies is likely to require increased investment. McKinsey & Company (2009) estimates that the annual incremental investment costs required to get the global economy on to an appropriate low-carbon trajectory would be EUR 320 billion by 2015. The IEA (IEA, 2008) and UNFCCC (UNFCCC, 2007) suggest a similar figure for the incremental costs of power generation in strong climate-change mitigation scenarios. However, the pace of the transformation may be constrained by the cost and/or availability of financial capital (given the risk characteristics of the investments involved) or incur a higher cost in terms of investment and employment displaced elsewhere in the economy.

A further caveat is that studies tend to focus on alternative energy supply scenarios rather than considering a broader range of alternatives, some of which could entail greater job creation still. For temporary counter-cyclical employment creation, higher spending in sectors with lower capital intensities than either conventional or renewable energy – such as education and health services – may be more effective (although perhaps more difficult to unwind when macroeconomic circumstances improve).

That is one reason why Strand and Toman (2010) express some skepticism about proposals for a green fiscal stimulus, particularly in developing countries. Road-building, for example, is relatively labor-intensive and can help to provide valuable infrastructure, but it is not particularly green. They also note that many of the studies for developed countries do not emphasize short-run employment creation, because of the lead times necessary for replacing capital in the energy sector. In their view, "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."

Overall, Strand and Toman conclude that there are likely to be trade-offs for employment generation, in the sense that programs that yield larger employment effects tend to lead to more employment gains for largely lower-skilled workers, so that the long-term growth effects are relatively small. Long-term development, including sustainable development, requires more of a focus for public investment on growth-enhancing infrastructure, as well as private sector investment, which is not necessarily labor-intensive. The argument for investing in initially labor-intensive low-carbon technology in order to benefit from experience, scale economies and learning by doing, thus driving costs down, is weaker for developing countries because they are less likely to have a comparative advantage in low-carbon innovation, at least in the energy sector.

Strand and Toman (2010) also review some of the small literature on green fiscal stimuli and job creation specifically in developing countries, noting that the evidence is scant and spotty. Studies largely focus on the direct effects of particular activities on employment. Barbier (2009) investigates the South Korean green stimulus while the UNEP/ILO/IOE/ITUC (2008) study looks at China's experience. What is most striking is the large variation in employment creation in jobs created per US$ billion spent. In South Korea, forest restoration is estimated to be highly labor-intensive, generating nearly eight times as many jobs per dollar as the least labor-intensive green objective, 'vehicles and clean energy.' In China, biomass spending is thought to be nearly 30 times more effective in generating jobs per dollar spent than wind power. That suggests that the focus on renewable energy and low-carbon manufacturing prevalent in studies for Europe and the USA may miss the opportunities for

employment creation from changes in land management and agriculture in developing countries, where these economic sectors are relatively more important.

Schwartz et al. (2009) considers direct employment effects of fiscal stimulus projects in three Latin American countries, Honduras, Brazil and Peru. Again, the variation in jobs created per dollar across the different projects considered is large. Water network rehabilitation and expansion in Honduras is much more effective (by a factor of more than ten) in creating jobs than hydroelectric schemes in Brazil, with rural electrification in Peru falling in between (the Honduran projects seem to be a lot more labor intensive than water resource management in South Korea).

Rutovitz (2010) carries out a detailed analysis of employment opportunities from a switch towards renewable energy and greater energy efficiency in South Africa, in the spirit of Rutovitz and Atherton (2009), a global study for Greenpeace. The focus is on direct employment but allowance is made for learning effects with new technologies that increase labor productivity (reduce the number of jobs supported) over time. Different scenarios are considered for how much of the plant and equipment needed is manufactured in South Africa and for how much South Africa supplies the rest of Africa with renewables technologies. Job losses in the coal industry are factored into the projections. A business as usual scenario from the International Energy Agency (IEA) is compared with (i) a South African government 'Growth Without Constraints' (GWC) scenario designed to reflect South Africa's energy future in the absence of climate change, with no oil constraints, and if no effort was made to internalize externalities, and (ii) an Energy [R]evolution scenario designed to reduce South African emissions by 60% by 2050 (compared with 2005). The authors estimate that the Energy [R]evolution scenario creates 27% more jobs than the IEA reference scenario and 5% more than the GWC scenario. Macroeconomic feedbacks are not analyzed and nor are costs. Yet the costs of job generation, including opportunity costs, can be substantial once macroeconomic consequences are taken into account.

Upadhyay and Pahuja (2010) examine the employment potential of renewable energy, especially wind and solar power, in India. Once again, its scope is limited to an estimate of direct employment effects, because it is difficult to assemble input-output tables with an appropriate breakdown of activities and to model induced macroeconomic effects. Unlike the developing country studies discussed above, the authors concentrate on estimates of

jobs created per megawatt of energy generation capacity, similar to the work by Kammen and others mentioned previously, drawing on India's National Action Plan on Climate Change. Such estimates are likely to show a bigger contrast between renewable and traditional energy than do estimate of jobs per dollar spent, because the cost of an extra megawatt of generating capacity is likely to be higher with the former. Unlike Strand and Toman, where the focus is on evidence from advanced industrialized countries, they conclude that low-carbon employment is one of the key co-benefits of promoting the renewables sector in India. They find that solar power is more labor intensive than wind power and better able to meet India's requirements for small-scale, off-grid power; biomass, 'green' transport and public works in water and forest management are also seen as attractive ways of achieving both employment and environmental objectives. One serious problem with Upadhyay and Pahuja's study is that the costs of different renewables scenarios are barely considered; the perspective is more of a quantitative planner. It is also interesting to note that the study explicitly rules out job losses in fossil-fuel power generation, arguing that "investment in fossil fuels is going to be a mainstay" of the Indian economy, at least in the nearer term, given the need to expand availability and reliability of electricity supplies as well as to pursue environmental objectives. This, together with an implicit assumption of surplus labor, allows the authors to dismiss job displacement as an issue.

Upadhyay and Pahuja's study is a contribution towards the Global Climate Network (GCN) report *Low Carbon Jobs in An Interconnected World* (GCN, 2010), which also covers China, South Africa, Brazil and Nigeria, as well as some developed countries. The study of China emphasizes the potential employment losses from the planned sharp reduction in the energy intensity of Chinese industry, but notes that this could be outweighed by increased employment in renewables and – quantitatively, much more important – the shift of the Chinese economy towards services and away from heavy industry. But the latter shift cannot be seen as a specifically 'green' objective. The study of South Africa focuses on direct job creation potential in renewables and draws the conclusion that "significant opportunities for employment lie in clean-energy sectors and can be harnessed if the South African government scales up its renewable energy ambitions." But again, this result flows from the fact that renewable energy production is more labor intensive than traditional energy sources. The question of the labor productivity and costs of renewables compared with traditional energy is not tackled.

The study of Brazil considers the employment consequences of fulfilling various targets for renewable energy supply, drawing attention to employment opportunities in hydroelectricity (notwithstanding Schwartz et al.'s finding that hydro is relatively capital intensive and poor in creating jobs per dollar spent), biofuels, biomass and solar power. The cost per job created is not calculated. The study concludes that renewable energy sources have a stronger potential in Brazil than is currently envisioned in official studies and government policies, both in terms of contributing to carbon dioxide mitigation and generating jobs.

The study of Nigeria considers the employment impacts of small-scale hydroelectric power, a key component of Nigeria's 2005 Renewable Energy Master Plan, and greater utilization of natural gas, a lower-carbon source of energy than oil and coal. Once again, estimates are largely restricted to direct employment effects, although there is some effort to estimate the number of jobs likely to be created in the supply chain of the natural gas sector.

Overall, GCN (2010) comes to the following conclusions:

(i) Clear, consistent and targeted government policy will help boost jobs numbers;
(ii) Finance is critical to the creation of low-carbon economic opportunities;
(iii) Training is critical to the development of low-carbon sectors;
(iv) Adjustment policies should also form part of the strategy; and
(v) More analysis is needed of how globalized markets will affect job creation.

The first conclusion is based largely on the fact that most of the policies analyzed in the contributing studies generate additional direct employment, but little attention is paid to employment displaced in high-carbon and other environmentally harmful activities or to macroeconomic constraints and the possibility of crowding out jobs. However, it does appear that several environmentally beneficial activities in developing countries could be considerably more labor intensive than traditional fossil-fuel-based energy supply.

The second conclusion emphasizes the need for capital to finance green investment, noting that the private sectors in many countries are currently not eager to lend. However, the potential constraint imposed by potential lack of profitability of green investment, with or without carbon pricing and other financial incentives, is not analyzed in depth.

The third conclusion, about training, is a useful reminder about possible bottlenecks in the labor market.

The fourth conclusion addresses the structural change induced by environmental policies and so acknowledges the need to take some account of the issue of job displacement.

The fifth conclusion very properly draws attention to possible leakages of green jobs and spending to other countries, to an extent that depends on endowments of skills, existing industry structure, the nature of the technologies newly deployed and the ways in which comparative advantage is exploited – a reminder that general equilibrium effects matter. Yet these are largely ignored in the green jobs literature. They may differ in developing countries from the effects in developed countries, as the next section discusses.

4. Modeling labor markets in developing countries

It has long been recognized that the standard neoclassical or Keynesian models may not adequately represent labor markets in developing countries. Thus the implicit assumption in many green jobs studies that there is Keynesian unemployment and no crowding out of jobs elsewhere in the economy by green fiscal stimuli may not be valid. But equally, the objection that employment is determined in competitive markets, implying that green jobs are likely to displace at least as many jobs elsewhere in the economy, may lack force because the assumptions on which it is based do not hold.

This issue is important for evaluating green policy initiatives' labor market implications and is hardly a new one. For example, half a century ago Lewis drew attention to the possible existence of surplus labor in developing countries, particularly in agriculture (Lewis, 1954). In a surplus labor economy, there is much less risk of crowding out employment when green projects are undertaken. Thus the estimates of direct employment creation in the green jobs literature might be less misleading for developing countries than for industrial economies close to full employment. But the situation is more complicated in 'dual' economies with modern and traditional sectors or three-sector economies with a traditional rural sector and both formal and informal urban sectors, as has also been long understood (Harris and Todaro, 1970; Fields, 1975; Mazumdar, 1976).

Other assumptions of the standard competitive labor markets model could also be relaxed. In one of the few attempts to do this, Babiker and Eckaus (2007) explore the impact of constraints on real wage adjustment and on inter-sectoral flows of labor in different regions of the world and find that China and India could be the countries most adversely affected by the structural change induced by carbon pricing, largely because these are the regions that need most reallocation of labor as a result of environmental policy.[3] It would be very useful to consider the implications of various models of labor market functioning more specific to developing countries (e.g. as reviewed by Behrman, 1999) for the employment and wage impacts associated with a shift towards green policies.

As an example, consider the model of Satchi and Temple (2009). As they point out, "At present, we know relatively little about how changes in sectoral productivity translate into labor market outcomes." Yet green policies appear likely initially to lead to lower productivity in the energy sector, with pervasive knock-on effects in the rest of the economy, unless at the same time other market failures, such as those involved in the provision of energy supply infrastructure, are corrected. Satchi and Temple set up a small-scale general equilibrium model, in the tradition of labor market search models, designed to characterize typical middle-income countries (their calibrations use Mexican data). There are three sectors: a formal urban manufacturing sector, an informal urban sector, and a rural sector. Underemployment – essentially, employment in the informal sector – arises because of job/worker matching frictions in the formal sector. The urban wage (in the formal sector) is endogenously determined, unlike in Harris and Todaro (1970). The rural sector is assumed to be perfectly competitive with constant returns to scale and full employment, thus ruling out the type of surplus labour considered in many low-income countries.

The authors consider the impact of productivity shocks in different parts of the economy. If green policies are thought of as having adverse impacts on energy sector productivity, it matters where energy sector jobs are located. Suppose they are in the formal urban sector, as would be the case if they are largely in regulated energy utilities. Then the size of the informal sector may increase (and definitely does not decrease) as a result. The urban

[3] The ways in which Babiker and Eckaus model real wage rigidity and limits on inter-sectoral labour flows can be argued to be inappropriate over the very long run associated with integrated assessment models. But their study nevertheless demonstrates the potential importance of these constraints.

unemployment rate goes up but rural-urban migration is reduced, pushing down agricultural wages. Total unemployment does not necessarily increase, because the movement of population to rural areas may reduce the denominator of the unemployment rate.

Green policies do not only change energy sector productivity. They may also lead to increased direct employment in the formal sector if, for example, there is a green fiscal stimulus aimed at the energy industry. In that case, one could simulate the impact in Satchi and Temple's model as a reduction in the size of the competitive formal sector (as workers are siphoned off into the non-competitive state-financed projects). Re-establishment of equilibrium would entail higher wages in the competitive formal sector, the growth of the formal sector as a whole, and increased rural-urban migration, with ambiguous impacts on the informal sector. That might in turn boost aggregate productivity, even if the state projects generated jobs with lower productivity than the rest of the formal sector; in the model, the marginal product of labor in the formal sector is 1.5 times that in the informal sector and 2.7 times that in the rural sector.

Green policies might also induce inward flows of capital (e.g. through the Clean Development Mechanism and other international climate finance arrangements). That would tend to boost formal sector employment. One could carry out other thought experiments in this vein. For example, adaptation to climate change in rural areas could be modeled as an adverse productivity shock in the rural sector. The impact of green energy policies on the price of energy (increasing them at least for a while) could be modeled as reducing productivity throughout the economy. The key point is that the overall effects of green policies on employment depend on the characteristics of the economy's labor markets and the nature of the policy interventions, including their funding, not just the input requirements of rival energy technologies.

Indeed, it would be helpful to consider the implications of a wider range of theories of labor market adjustment in different types of economy. After all, there still remains much debate about how best to characterize business cycles and labor market adjustment in developed countries. Are workers always on their labor supply curves, as in standard real business cycle theory? What are the dynamics of job creation in a Mortensen-Pissarides world of job search in a world of imperfect information and search externalities (Pissarides, 2009)? Is Keynesian unemployment caused by wage and price rigidities and, if so, which matters

more, and is nominal or real rigidity more important? If the source of the market malfunctioning at the macroeconomic level is not understood, it is difficult to work out what effect a second-best employment creation policy such as new environmental investments would have (as opposed to a first-best policy of removing the offending rigidity). All of these questions are relevant to investigating the likely labor market consequences of green policy initiatives ranging from carbon pricing to changes in the pattern of government subsidies to energy to deficit-financed green infrastructure investments.

Understanding the interaction of business cycles and labor markets better would help to establish what the scope is for green fiscal stimuli to counter increases in involuntary unemployment and underemployment in developing countries. Although governments in developing countries may on average have less of a capacity to time and manage fiscal stimuli appropriately (Kraay and Servén, 2008), business cycles may be more of a problem in developing countries, especially those engaged in international commodity trade, than in developed economies (Kraay and Ventura, 1998; Otero, 2000). Arguably, development economics has not taken sufficient account of the importance of fluctuations in aggregate demand, instead paying more attention to capital accumulation and technological innovation (Dutt, 2007).

Taking a much longer-term perspective, further analysis is needed of the scope for inducing higher long-run growth in developing countries by raising the rate of innovation. That could in principle speed up the re-allocation of labor inputs to more productive sectors of their economies, reducing underemployment and increasing real wage growth (if the new skills necessary are developed through appropriate training). Although the literature on green jobs tends to focus on the current characteristics of renewable energy supply and energy efficiency, integrated assessment modeling of climate-change mitigation is paying more attention to induced technological progress in low-carbon technologies. Are developing countries going to depend on spill-overs from R&D and learning in developed countries, as is largely the case in the WITCH model (Bosetti et al., 2006), or can they benefit sooner, for example, from advances in technologies more fitted to developing country circumstances (e.g. biofuels in Brazil, concentrated solar thermal power in North Africa, forest management in Indonesia)? Can developing countries with large manufacturing sectors benefit from a new global Industrial Revolution driven by a Schumpeterian search for competitive advantage (Perez, 2002)? Several of the jobs studies for countries such as South

Africa, Brazil, China and India allude to the possibility, but the long-run dynamics of green growth are still not fully understood. There is of course a downside to gales of competitive destruction and a risk that more rapidly shifting comparative advantage will give rise to more abrupt structural change, putting strains on the operation of labor markets.

Besides innovation, there are other areas of policy, such as network infrastructure provision, where there is also a presumption that private markets will provide less investment than is socially desirable. Here too, the consequences of new policies for labor markets will be very largely dictated by the way in which those markets function.

5. Heterogeneity of developing countries

The previous section of this paper noted the importance of recognizing the different circumstances of developing countries compared with developed ones. But there is much variation across developing countries, too, not least with respect to the likely ease of transition to a world of low-carbon growth. For example, the scope for developing a comparative advantage in the production of equipment for low-carbon electricity production depends on the manufacturing base of the country concerned and whether there are scale and learning economies in the particular technology. Thus the Greenpeace/EREC (2011) study envisages that, in its Advanced Energy [R]evolution scenario, 20% of the growth in renewable capacity in the rest of Africa by 2020 will be supplied by South African manufacturing, and by 2030 30%. Some countries have a comparative advantage in particular renewable energy sources because of natural endowments. Brazil, for example, has the right climatic conditions and soils to give it a substantial cost advantage in biofuels, although other characteristics of the Brazilian economy also help (Kojima and Johnson, 2005).

The developing countries that currently produce a high level of greenhouse gas emissions per unit of GDP face a difficult challenge of structural adjustment. They are the ones in which more labor is likely to have to be reallocated from currently GHG-intensive activities, either by switching technologies within an industry or by moving labor between industry sectors. Given the importance of carbon dioxide emissions from energy production, energy-intensive economies will comprise a large part of this group. The following scatter diagrams illustrate the wide variation across developing countries according to measures of carbon

dioxide emissions per unit of GDP and energy use per unit of GDP. Lower-income countries in Europe, Central Asia and the Middle East take up places at the top of the rankings.

Figure 1: Carbon dioxide emissions intensity and per capita income

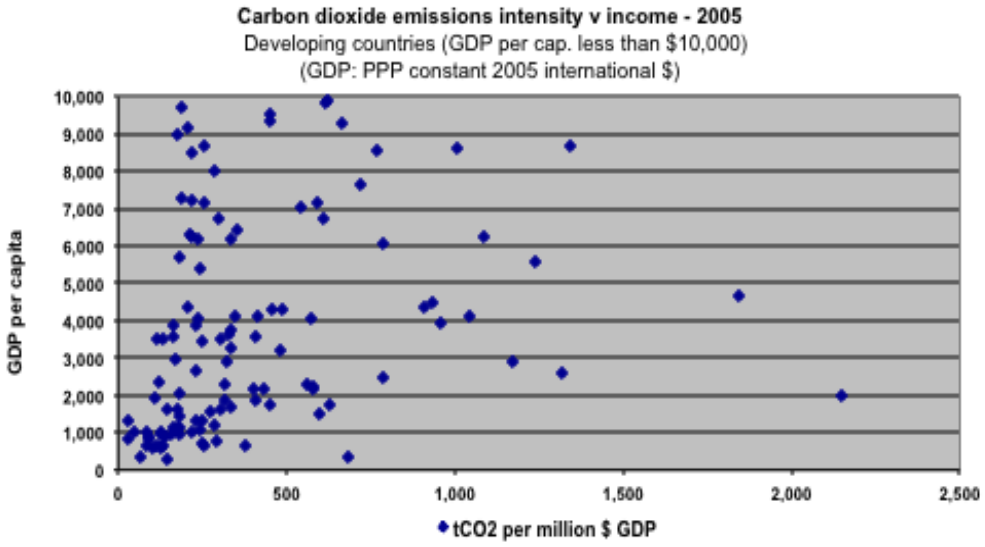
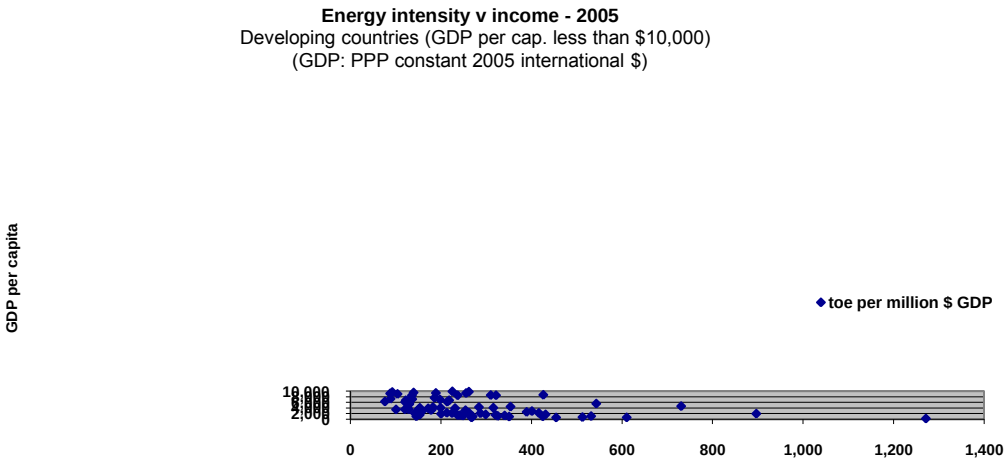


Figure 2: Energy intensity and per capita income

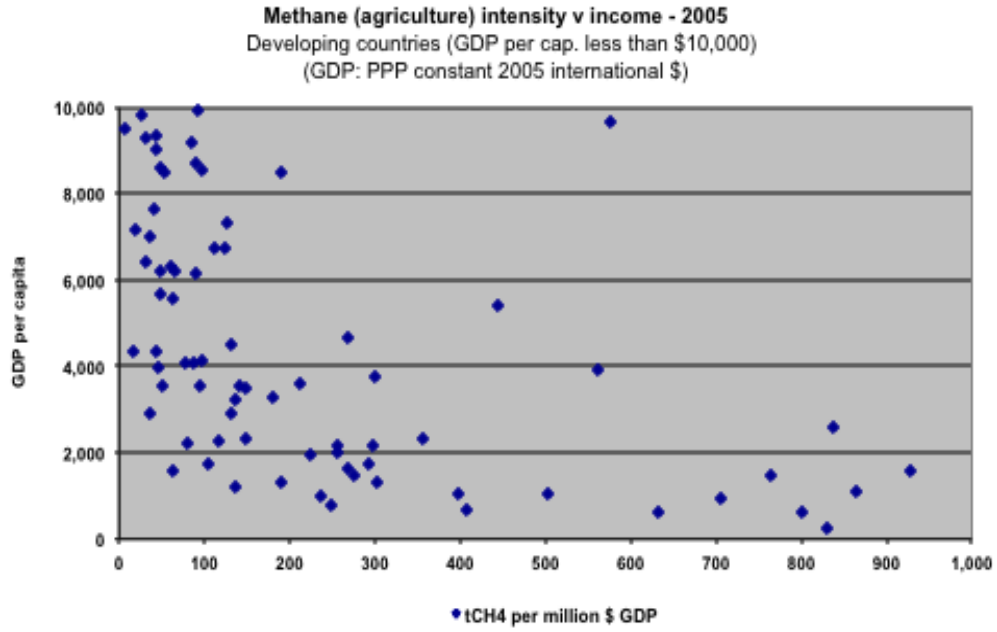


Endowments of fossil fuels combined with industrial development strategies that have favored carbon-intensive industry make a transition to low carbon much more challenging (EBRD, 2011). If such economies impose a carbon tax, the standard economic policy

instrument to internalize the greenhouse gas externality, the relative returns to different factors of production are likely to change. The few empirical studies focusing on how carbon taxation might affect factor returns suggest that the incidence of a carbon tax is likely to be regressive when emission abatement measures are capital-intensive (See Fullerton and Heutel (2007) and Fullerton and Heutel (2010), who calibrate analytical general equilibrium models for Japan and the United States respectively). Countries such as Kazakhstan and Mongolia with a much larger-than-average proportion of the labor force in mining and energy supply are more likely to suffer as a result of this adjustment and also from the difficulties of reallocating displaced labor to other sectors emphasized by Babiker and Eckaus (2007).

Similarly, some lower-income countries produce relatively high levels of methane from agriculture per unit of GDP (Figure 3), although data are patchy and often out of date. The substantial changes in agricultural practices and waste management that are needed pose larger adjustment problems in these countries.

Figure 3: Methane emissions intensity and per capita income



6. Skills for green growth

The emphasis in this paper so far has been on changes in the quantity of labor demanded or supplied as a consequence of adopting 'green growth' policies. But the skills needed in the labor force are likely to be affected as well. If the availability of the skills required along green growth trajectories is inadequate, that could place a major obstacle in the way of the transition to green growth.

Fankhauser et al. (2008), in their review of the literature on climate policy and jobs, note that there is relatively little information on the productivity of jobs created and destroyed by climate-change policies. There is even less on their pecuniary and non-pecuniary attributes. CEDEFOP (2009) complains that "We have not paid enough attention to the social dimension of sustainable development: its implications for employment, training and skills." Even in countries with relatively good labor market data, it is difficult to identify the jobs the content of which is most likely to be affected by green growth policies. For example, Hatfield-Dodds et al (2008) note that in Australia "current information on green skills and workforce capabilities is very poor;" there are some data for renewable energy and construction trades but little for transport and agriculture.

Perhaps the most thorough study of green growth and skills so far is ILO/CEDEFOP (2011), which reports the results of 21 country reviews and provides a synthesis of key findings. The study notes that the demand for skills is being affected in three ways by the transition to green growth.

First, there is induced structural change across industries, increasing the demand for the skills specific to expanding industries such as renewable energy and reducing the demand for skills such as those associated with coal-mining. This 'green restructuring' brings with it the usual challenges to policy-makers trying to facilitate restructuring and to reduce the labor market adjustment costs, including those resulting from a changing skill mix. Many of the expanding industries are likely to be using new products and processes, reflecting the transition to low-carbon technologies, so the generic skill requirements of many of the new jobs created are likely to be higher than average as they have to allow for assimilation of unfamiliar tasks and working methods and 'learning by doing.' It would appear, however, that a larger proportion of jobs in the renewable energy sector and in energy efficiency are low skilled than in the fossil-fuel energy sector (Pollin et al., 2009). The oil and gas industries

tend to have relatively well-paid workers and a high proportion of highly qualified engineers and technicians. Energy efficiency improvements tend to require relatively unskilled construction labor. But there is much heterogeneity, with, for example, smart grid technology management requiring more input from high-level engineering services than do building retrofits. In developing countries, re-afforestation is an important potential source of jobs for low-skilled rural workers.

Second, some new occupations are emerging, such as photovoltaic fitters and carbon-footprint assessors. But there appear to be relatively few unique green skills.

Third, the content of many existing jobs in existing industries is changing to reflect facets of the transition to green growth, such as increasing emphasis on energy efficiency, switching from fossil fuel sources to renewable energy and producing capital equipment for expanding green industries. In agriculture, low- and no-till agriculture and reduced use of fertilizers and pesticides will entail changes in farmers' practices, as will increased production of biofuel crops and efforts to increase forest cover. The ILO/CEDEFOP report argues that this third channel is likely to have the most pervasive effects on labor markets and this seems particularly likely to be the case in many developing countries. More generally, green jobs appear to be very diverse in their skill requirements, both with respect to the sophistication of the skills required and their degree of novelty.

Recent reports such as ILO/CEDEFOP (2011) and OECD (2011b) have found that skill shortages are already impeding the transition to green growth. The OECD draws attention to widespread skill shortages in energy-efficient construction and retrofitting; renewable energy; energy and resource efficiency; and environmental services. Particular countries have reported specific bottlenecks, such as the shortage of skilled PV workers in Germany and the lack of design engineers for smart grids in the UK. ILO/CEDEFOP argues that there are several reasons for these reported shortages, including the underestimation of the growth of certain green sectors, the general shortage of scientists and engineers, the low reputation and attractiveness of some sectors important for the green transition such as waste management, and a shortage of teachers and trainers in environmental services. But, as the OECD writes, "it is difficult to assess how general and severe these green skill shortages are based on evidence from highly diverse case studies."

The problems that can arise when training provision is not up to the challenge of the induced structural change are illustrated by the Australian experience with a new Home Insulation Program introduced in February 2009 as a key part of the Australian government's fiscal stimulus (Australian National Audit Office, 2010). The Program was designed partly to generate jobs for lower-skilled workers in the housing and construction industries. At the start of the program, only supervisors were required to satisfy one of three minimum competences – prior experience in the insulation industry, qualifications in an approved trade, or insulation-specific training. The program proved popular. At its peak, demand was running at almost 2 ½ times the anticipated level and some 1.1 million roofs out of 2.7 million eligible were insulated. But fires, fitters' deaths and reports of fraud undermined public confidence and it was cancelled in February 2010. A subsequent sample of inspections revealed that nearly 30% of installations had some level of deficiency. Investigations showed that low skill levels in the industry, inadequate provision of training and poor management of the program were among the factors responsible. The importance of competent project management and national policy-making in this case is a reminder of the key role of higher-level management and planning skills in a policy-induced transition to green growth that is likely to take sustained effort and policy credibility over a long period.

In developing countries, it may be more difficult to fulfill the requirement suggested by UNEP and others that green jobs should be 'decent' jobs. Upadhyay and Pahuja (2010) make this point in the Indian context, noting that "jobs like that of unskilled labor in biofuel and biomass production could be numerous but of low quality as they barely provide subsistence wages and have difficult work conditions." They suggest that environmental activities under India's National Rural Employment Guarantee Act could be particularly beneficial in creating jobs for the unskilled. In the current circumstances of the Indian economy, that is desirable for reasons of equity and poverty reduction even if it does not increase the productivity of the employed labor force. But Schwartz et al (2009), in their study of Peru, Brazil and Honduras, draw attention to the rather skills-intensive nature of the projects undertaken as part of those countries' fiscal stimuli, giving rise to a concern that a more aggressive stimulus could run up against skills bottlenecks. GCN (2010) acknowledges the need in South Africa to train workers in new skills if the renewables sector is promoted as part of an aggressive green strategy and notes the risk that a lot of the new manufacturing and construction jobs associated with expansion of renewable energy would

be located outside of South Africa, given its limited manufacturing base and availability of appropriate skills.

The limited evidence in this area suggests that making green jobs decent is likely to require greater outreach by training organizations and educators. The increasing appreciation of the need to tackle environmental externalities of economic activity, especially climate change, draws attention to pre-existing market failures in the provision of skills as well as in stimulating innovation and satisfying infrastructure needs. Many of the skill shortages already reported in connection with green growth strategies appear to result from generic failings in education and training and reflect long-standing issues such as the lack of incentives for employers to invest in developing the transferable skills of their workforces, the lack of access to time and finance for training on the part of the disadvantaged and the stickiness of relative pay rates. In many countries, public employment programs are likely to be part of the solution (Lieuw-Kie-Song and Lal, 2010). Box 3 presents the special measures that the ILO and CEDEFOP argue are necessary for labor markets to respond effectively to green growth policies.

Box 3: Measures necessary to equip developing countries with the skills for green growth

ILO and CEDEFOP (2011) argue that developing countries need special measures to equip them with the skills for the transition to green growth:

(i) Capacity building for employers in the informal economy and micro and small enterprises to enter green markets in localities where they are most needed

(ii) Entrepreneurship training and business coaching for young people and adults to start up green businesses in conjunction with microfinance projects

(iii) Environmental awareness among decision-makers, business leaders and administrators as well as institutions of formal and non-formal training systems

(iv) Capacity-building of tripartite constituents to strengthen social dialogue mechanisms and to apply these to dialogue about accessibility to training for green jobs

(v) Increased capacity of formal education and training systems and institutions to provide basic skills for all and to raise the skills base of the national workforce; this includes improving apprenticeship systems and building synergies with NGOs that provide education and training.

7. Conclusions

The term 'green jobs' means different things to different people. One serviceable definition equates it with the employment in a narrowly defined set of industries providing environmental services. Quantitatively, these industries amount to a small share of total employment – of the order of 1%, but varying according to definition. This type of definition provides a useful basis for benchmarking countries' efforts in the environmental policy arena and for understanding these industries better. But these objectives have not been at the heart of the literature on green jobs and there is scant information on developing countries' employment in these industries. Instead, studies have tended to focus on the employment consequences of introducing public policies to correct environmental externalities, especially anthropogenic climate change. This is more interesting from the policy-maker's perspective as it brings labor market behavior into the calculus when assessing the merits of alternative courses of action against standard yardsticks of appraisal (e.g. measures of productivity, well-being and equity). It is also in principle a broader approach, potentially covering jobs created and destroyed across the whole economy – although many studies take a much narrower approach in practice.

Renewable energy supply, an increase in which is a key component of global and local climate-change policies, appears to be likely to be more labor intensive than traditional fossil-fuel-based supply, per megawatt and per dollar, although there are questions about how labor requirements are likely to evolve over a plant's life and as technological progress takes place. But it is not likely to be more labor intensive than several other activities on which governments could spend in order to generate social benefits. Energy efficiency improvements also appear to be labor-intensive, drawing heavily on relatively unskilled labor in the construction sector. There are many attractive opportunities for developing countries in both these areas. However, the implications of the current lower labor productivity of these activities for public finances, aggregate productivity, energy prices and the profitability of private-sector activity are not generally examined and need to be. The

fact that employment has a social cost (reflected in the economist's concept of a shadow price of labor) should be borne in mind.

There are important differences across types of economy due to different industry structures, labor market institutions and endowments. The challenges for some developing countries posed by the transition to green growth are particularly difficult and the prospects for their labor markets more daunting, given the structural changes that will be needed. Among these are the countries that at the moment have a comparative advantage in fossil-fuel production, particularly those that have built their industrial development strategies around cheap carbon-based energy.

Less attention has been paid to the labor market consequences of other environmental policies, such as support for biofuels and low-carbon land use. These are likely to be relatively much more important in low-income countries than in high-income ones. Some evidence suggests that they are likely to be more labor intensive than renewable energy supply too. More research is needed into their labor market implications, including the possible impacts on rural-urban migration.

In practice, most of the literature has focused on direct employment created, with more cursory or no treatment of indirect and induced jobs creation, especially that arising from macroeconomic effects of policies. The perspective taken is often that of project-based cost-benefit analysis where the project can be assumed to be too small to affect market prices and labor supply can be assumed to be highly elastic. The costs and benefits are often not fully enumerated either. This seems a major drawback in the 'green jobs' debate, given that nations are being encouraged to engineer non-marginal changes in the structures of their economies, particularly those connected with energy supply and demand. A greater emphasis on 'top down' modeling that incorporates important features of the macro-economy is needed. This can be combined with the wealth of detailed microeconomic information provided by 'bottom up' modeling from an engineering or project-based perspective. Given the focus on environmental policies in the 'green jobs' literature, 'top down' models that allow for the possibility of market failures are required. And given the very distant time horizon for climate-change policies, examining the implications of alternative theories of long-run growth is also desirable. Thus there should be synergies

with research on the sources of long-run growth in developing countries and the debate about per capita income convergence.

Most important, more attention needs to be paid to how labor markets work at the macroeconomic level. It is not surprising that this should be central to the determination of the employment consequences of any given set of economy-wide policies. Several studies have implicitly or explicitly used a framework of Keynesian involuntary unemployment. This is not necessarily inappropriate for developing countries given their susceptibility to business cycle shocks. But further thought about what modern macroeconomic theory implies for the workings of labor markets is warranted. If, for example, involuntary unemployment is the result of rigid real consumption wages, climate-change policies, by increasing the price of carbon-intensive goods and services, could end up increasing unemployment, notwithstanding the labor intensity of new investment projects.

Another aspect of the functioning of labor markets that needs to be taken into account is human capital formation. There are generic problems afflicting the provision of skills, which take on greater significance when policymakers are trying to induce a pervasive structural change in the economy. Already skill shortages are being reported in industries and occupations likely to benefit from green policies. Perhaps the most important of these are the high-level skills necessary to manage large-scale green policy interventions and the associated large-scale projects over a long period of time in a way that will build the credibility of green growth aspirations while allowing for learning and policy improvement over time. This is a big challenge for all countries but particularly for those in which sustained constructive collective action has proved difficult in the past.

For developing countries, it is also desirable to consider the implications of labor market models tailored to their particular circumstances – for example, surplus labor models and multi-sector models where each sector's labor market behaves differently. That may make environmental policies look even more attractive than they do in developed countries, where in some sense labor is relatively scarcer. It may also point to ways in which environmental policies have different consequences in different sectors. Thus the general equilibrium consequences of a given amount of direct job creation in a highly regulated energy utility may be completely different from the consequences of the same amount of direct job creation in rural land management.

What does this imply for governments in developing countries contemplating introducing new environmental policies? Strand and Toman (2010) conclude that there are few obvious candidates for triple-win policies that deliver simultaneously strong benefits for short-term economic recovery, longer-term growth, and long-term environmental benefits.[4] Nevertheless, there is a case for opportunistically speeding up appropriate social projects (environmental or otherwise) when resource constraints are relaxed, for example, because of an adverse shock to private aggregate demand (Bowen and Stern, 2010). Such a shock can increase the wedge between the shadow wage in an economy and the actual wage, warranting more projects being undertaken by the public sector. However, it need not necessarily do so. If the projects are difficult to finance because of constraints on governments' borrowing or tax-raising capacity, the shadow wage may not be lower than the actual wage. The more labor-intensive green projects will naturally constitute a larger share of the temporary incremental spending. But low-labor-productivity projects should not be adopted unless they are profitable at the relevant shadow prices (including not only the wage but the carbon price and the optimal subsidies for learning and R&D). The policy-maker should not rank projects by employment per dollar spent, choosing simply those with the highest rank. Such an approach risks policy-makers forgetting that employment costs have a social cost associated with them.

More generally, there may be persistent wedges between the shadow wage and the actual wage, particularly in developing countries with segmented labor markets, warranting a bigger and longer-lasting boost to green projects with high labor content (even though the shadow wage is positive). Whether that would lead to a larger rise in green spending than other types of spending (e.g. health and education) is difficult to determine without more detailed comparisons of technologies across a wider range of sectors. And there is a danger that, without appropriate environmental pricing, counter-cyclical spending to increase employment could lock in carbon-intensive technologies (e.g. spending on road-building and fossil-fuel extraction). But the importance of climate change mitigation and the slow development of low-carbon and other environmental policies up until now, together with the relative labor intensity of at least some green investment, suggest that there are likely to be many opportunities to make investments that have both environmental and labor market

[4] Strand and Toman also invoke Tinbergen's Principle, that if a government has n objectives it needs n policy instruments to achieve them efficiently. At the same time, the optimal setting of an instrument is not necessarily independent of changes in other instrument settings. Thus a change in the wedge between the shadow wage and the actual wage might, for example, entail changes in carbon pricing or public infrastructure spending.

pay-offs. A policy-induced structural change of this sort, just like an exogenous structural change (induced for example by globalization), requires attention to active labor market policies with respect to training, education and transitional income support.

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