Looking for green jobs: the impact of green growth on employment

Alex Bowen and Karlygash Kuralbayeva

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The authors

Dr Alex Bowen joined the Grantham Research Institute on Climate Change and the Environment, London School of Economics and Political Science, in 2008 as a Principal Research Fellow, after many years at the Bank of England, most recently as Senior Policy Adviser. He first became involved in climate change issues when seconded as lead economist to the Stern Review of the economics of climate change. His research interests include the design of public policies to reduce greenhouse gas emissions, 'green' growth and the macroeconomic and labour-market aspects of climate-change policies. He has been a consultant to the EBRD, OECD, World Bank, ADBI, DFID and DECC among others. Dr Bowen has a BA in Economics from University of Cambridge and a PhD in Economics from the Massachusetts Institute of Technology, where he studied on a Kennedy Scholarship.

Dr Karlygash Kuralbayeva joined the Grantham Research Institute on Climate Change and the Environment, London School of Economics and Political Science, in October 2012 to work on macroeconomic aspects of climate change policies, and interactions between environmental policies and business cycles. Previously she held a research position at OxCarre (Oxford Centre for the Analysis of Resource Rich Economies), University of Oxford, worked as consultant at the World Bank, and as an economist at Credit Suisse (London). Dr Kuralbayeva holds a PhD in Economics from the University of Oxford.

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Executive summary

There are many claims and counter-claims about whether green growth creates or destroys jobs. But fully assessing the consequences of environmental policies for employment presents a considerable challenge, and at present it is not possible for policy-makers to assess conflicting claims about the quality and quantity of green jobs that have already been created, or may be created in the future. One approach would be to focus on changes in employment in industries that provide environmental goods and services. Another would be to count the jobs created when firms adopt technologies with less environmental impact and switch to less polluting inputs, regardless of their primary outputs. Both approaches can be helpful for assessing the direct impact on jobs and the scale of structural change required by the transition to green growth.

But green policies also affect labour markets indirectly through supply chains and through changes in overall demand. The destruction of 'brown jobs' in polluting industries should also be taken into account. The consequences of green policies for labour markets working through macroeconomic channels – such as changes in labour productivity and the costs of employment – are often overlooked.

This policy brief argues for a greater focus on these indirect channels, taking into account a country's particular economic structure and labour market institutions. This is particularly important for comprehensively analysing the impact of green policies in developing countries.

In the light of these observations, policy-makers should:

- Accelerate international efforts to establish common statistical standards for measuring the number of existing green jobs, building on the frameworks provided by the UN System for Integrated Environmental-Economic Accounting and the International Conference of Labour Statisticians (ICLS) recommendations for classifying jobs.
- Restore the momentum behind the compilation of national green jobs statistics in countries where it has slackened, notably the United States and United Kingdom.
- Consider ways in which international agencies such as Eurostat and the OECD, and countries that already report regularly, can help developing countries improve their statistics on green jobs.
- Assess regularly – using improved data – the pace at which the demand for workers in environmental and resource-management services is changing, comparing this with the normal degree of flux and change in labour markets.
- Assess the likely labour market impacts of economy-wide green growth using a macroeconomic framework, given that climate change and other green growth policies are likely eventually to constitute a large, non-marginal change in the policy environment for firms and households.
- Develop strategies for coping with employment losses in the sectors that will suffer from green growth policies, remembering that this may include sectors hit by higher real prices for currently carbon-intensive inputs (such as electricity, aluminium and cement).

1. Introduction

It has often been argued that job creation is one of the important benefits of green growth policies – that is, policies to foster economic growth and development while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies (OECD, 2011). For example, UNEP (2011) claims that the greening of economies is a net generator of decent jobs – good jobs that offer adequate wages, safe working conditions, job security, reasonable career prospects and worker rights.[1] Leaders of the UNFCCC secretariat and the International Labour Organization (ILO) have argued that taking action to mitigate climate change creates high-quality employment (Figueres and Ryder, 2014). Labour market aspects of green growth have been a key concern of institutions promoting development (see, for example, World Bank, 2012, and ADB/ADBI, 2013). The OECD has also suggested that investing in green activities has significant potential to create jobs (OECD, 2011). The global economic downturn triggered by the world financial crisis of 2008-09 gave rise to many proposals for green fiscal stimuli to promote growth and, in particular, jobs (see, for example, Pollin et al., 2008).

Yet it has also been claimed that environmental policies may have much less attractive consequences for labour markets. Michaels and Murphy (2009), for example, conclude that it is highly questionable whether a government campaign to spur green jobs would have net economic benefits. Hughes (2011) criticises what he called the 'myth' of green jobs, adding 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). Morriss et al. (2009) complain that the green jobs literature is "rife with internal contradictions, vague terminology, dubious science and ignorance of basic economic principles."

This debate is difficult to resolve at the moment because of the paucity of empirical evidence and good data. Martinez-Fernandez et al. (2010) suggest that the impacts of climate change and of mitigation and adaptation policies on labour markets are still largely unknown. Deschênes (2013), in a review of the literature, concludes that "…there is little quantitative evidence on the environmental benefits associated with green job policies, and whether these benefits are sufficient to justify the costs of the green policy investments. There is a glaring lack of quality real-world microeconomic data on green jobs, and characteristics of 'green' workers."

This policy brief considers how this situation can be improved. First, it reviews some of the attempts to offer a statistical definition of green jobs, emphasising the importance of accelerating the development and application of an internationally agreed statistical framework. This is important if policy-makers are to understand fully the structural changes that policies to promote the green economy will bring about. Around the world, nationally appropriate mitigation actions are being put in place as part of the mounting global effort to contain climate change, yet their consequences for working people are not properly understood.

The policy brief then discusses efforts to assess the impact of some specific green policies on jobs. It is evident from this discussion that assumptions about how labour markets work in the aggregate play an important role in influencing the conclusions drawn about the overall labour market impact of green policies. But labour markets work differently under different macroeconomic circumstances and in different places. In particular, different assumptions about how labour markets work may be appropriate for the analysis of developing countries and of advanced industrial economies, depending on their institutions and endowments, a theme explored next in sections 4, 5 and 6 of this policy brief. Finally, some conclusions are drawn for policy-makers.

1 This is the International Labour Organization's definition of 'decent work.'

2. Defining green jobs

There is as yet no single universally 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 avoid the term completely. In a broad sense, however, green jobs can be regarded as those associated with environmental objectives and policies. Counting green jobs gives a sense of the magnitude of the implications of those objectives and policies for employment and structural change in economies. Statistics are needed for planning, designing and evaluating environmental and labour market policies, and for assessing the extent to which the economy is responding to various public policies and incentives (ICLS, 2013).

Some definitions of green jobs or related concepts focus on occupations and skills with an identifiable environmental goal, but most focus on employment in industries (or specific projects) that produce environmentally beneficial products. 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 (such as building railways). IRENA (2014), for example, estimated that renewable energy jobs reached 6.5 million in 2013, with the largest employers being, in decreasing order, China, Brazil, the United States, India, Germany, Spain and Bangladesh. To put this figure in perspective, this compares with total global employment of just over 3 billion (ILO, 2015).[2]

A consensus is emerging on an appropriate definition, focusing on a subset of industries producing environmentally desirable outputs. Several 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 (for example, 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 per cent of total paid employment in Europe (European Commission, 2007). 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. Many jobs are not counted as green, despite the nature of the goods and services they help produce. For example, jobs in the car industry are excluded, even though some may be devoted to developing low-carbon vehicles. A Eurostat handbook providing definitions, data collection methods and examples for the environmental goods and services sector (EGSS) was published in 2009 (Eurostat, 2009). For 2012, with extrapolation from reported figures, Ecorys (2012) estimate that the total number of people working in eco-industries in the European Union (a broadly similar definition to Eurostat's) was around 3.4 million (around 1 per cent of the total workforce aged 15-64).

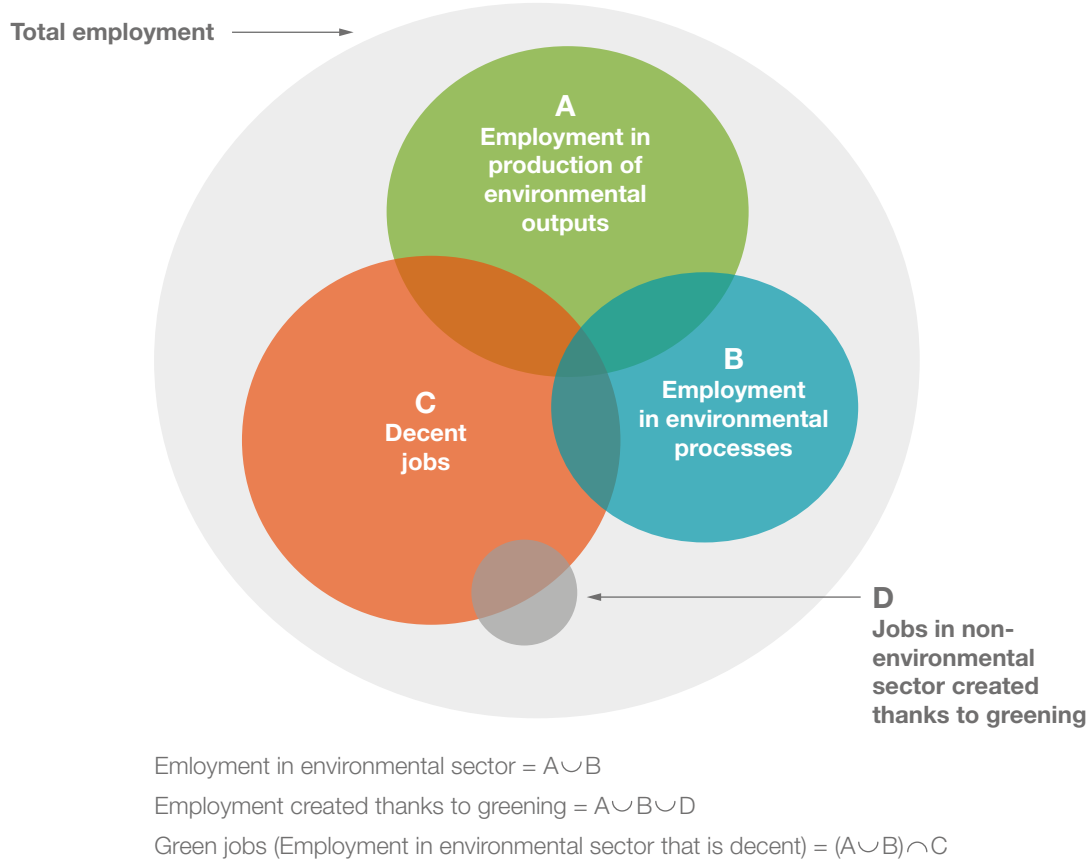
2 Rutovitz and Atherton (2009) estimated that about one fifth of jobs worldwide in electricity generation in 2010 (around 1.9 million jobs) would be in the renewables sector.

The International Labour Organization (ILO) has proposed an additional criterion that green jobs need to offer decent work (UNEP/ILO/IOE/ITUC, 2008). However, this conflates different social objectives in one term. The extra criterion 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. This has led to controversy, for example, about the role of marginalised waste-pickers in recycling and fighting climate change (see the Global Alliance of Waste Pickers website: http://globalrec.org/).

At a global level, the Eurostat work has allowed the incorporation of the EGSS into the UN System for Integrated Environmental-Economic Accounting, which was revised and became an international statistical standard adopted by the U.N. Statistical Commission in 2012.[3] As far as EGSS jobs are concerned, 'Guidelines concerning a statistical definition of employment in the environmental sector' were adopted at the 19th International Conference of Labour Statisticians (November, 2013) to help countries develop statistical standards and methods for green jobs, the green economy and employment in the environmental sector and improve international comparability. These are consistent with the approach taken by Eurostat. Figure 1 below (from the Annex of ICLS, 2013) helps to distinguish different categories relevant to the green jobs debate. The focus of statisticians developing a statistical reporting framework is on employment in the production of environmental outputs and environmental processes (jobs in sectors A and B in the diagram). This is not sufficient in itself to establish whether the jobs are 'decent' jobs in the ILO sense (sector C) or what the induced effects of green policies are outside the environmental sectors (sector D). Nevertheless, this is a vital first step in standardising measurement.

3 The central framework is described at: http://unstats.un.org/unsd/envaccounting/seeaRev/SEEA_CF_Final_en.pdf. Further discussion of the challenges of measuring EGSS activities can be found in UNEP (2014).

Figure 1. Schematic relationships between total employment, employment in the environmental sector and decent work



Source: Annex of ICLS, 2013

The Bureau of Labor Statistics (BLS) in the United States began to take a similar approach a few years ago. Under its 'output' approach, it considered green jobs as 'jobs in businesses that produce goods and provide services that benefit the environment or conserve natural resources.' These goods and services are sold to customers, and include research and development, installation and maintenance services. Green goods and services fall into one or more of five groups:

- Energy from renewable sources
- Energy efficiency
- Pollution reduction and removal, greenhouse gas reduction, and recycling and reuse
- Natural resources conservation
- Environmental compliance, education and training, and public awareness.

To implement the output approach, the BLS carried out a Green Goods and Services (GGS) survey to identify whether establishments in these sectors (325 industries out of 1083) were producing any green goods and services and, if so, the number of associated jobs. The method did not simply designate an industry as green and count all jobs in that industry as GGS jobs, since establishments in the industry may also produce goods and services that are not considered green. Only the employment directly associated with the production of green goods and services within these selected industries were considered GGS jobs under the BLS definition. The BLS recognised that there may be some GGS employment in other businesses and government agencies in their secondary activities, but these were not counted within the GGS survey scope.

On this basis, green jobs comprised 2.6 per cent of the US workforce in 2011 (a share that had increased by 0.1 percentage points since 2010). Unfortunately, because of US budget cuts, the BLS decided to discontinue all 'measuring green jobs' products – data on employment by industry and occupation for businesses that produce green goods and services; data on the occupations and wages of jobs related to green technologies and practices; and green career information publications – after only two years of publication.

The development of statistics for the green economy also seems to have suffered in the United Kingdom. In 2010, the ONS said in its Economic and Labour Market Review (ELMR) that, "There is a clear requirement in the United Kingdom, and internationally, to measure the progress towards a green economy, and within this to understand the contribution of the environmental goods and services sector to the economy and the potential for growth" (Livesey, 2010). The publication in the ELMR of a study assessing the feasibility of measuring this sector in line with the definitional framework proposed by Eurostat was promised some time ago. Unfortunately, the ELMR was discontinued. The latest web-published Environmental Accounts, for 2014, state that estimates of turnover, value added, employment and exports of the environmental goods and services sector will be published in the 2015 UK Environmental Accounts.

Overall, there has been progress towards standardising a definition of green activities and the jobs associated with them. The Eurostat and UN statistical frameworks are being made consistent and European countries are beginning to collect better data. The data is patchy and the bases for data collection are varied and subject to frequent revision. So far, they suggest that green jobs are a small but non-negligible fraction of the workforce, bigger in developed than developing countries, and becoming more common. As Ecorys note in a study for the European Commission's Environment Directorate-General (Ecorys, 2012), "The general trend is of a growing number of 'green jobs', with the majority dependent on the environment as an input." The market for environmental and resource-management goods and services is expected to grow faster than average but the absolute increases in the numbers of green jobs have been modest so far. Less is known about the state of green jobs in developing countries than in advanced industrial countries, especially Europe, but the greater emphasis on environmental regulations in the latter suggests that the number of green jobs in the former, outside the renewable energy sector, will not have increased sharply.

The message for policy-makers is that structural changes in labour markets due to green policies have been relatively small so far. But better statistics, agreement on common definitions and the further study of methods to estimate the number of green jobs are urgently needed, especially if the pace of climate change mitigation is to be ramped up.

3. Measuring the impact of green policies on jobs

Moving beyond counting heads

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 modelling of the policies to compare the number of jobs and composition of employment with and without the application of the policy of interest (for example, investment in electricity production from renewable energy). Some studies count only jobs directly created or destroyed by the policies ('direct' employment effects) while others include jobs created or destroyed in the supply chain for the products and services supported by green policies ('indirect' employment effects).

The main types of policy that have been considered in the literature include investment in plant, equipment and infrastructure embodying green technologies (primarily low-carbon technologies, given the focus of much of the empirical work on the environmental problem of human-induced climate change) and environmental taxes (primarily carbon taxes, the removal of energy subsidies and payments to subsidise renewable energy production). These are discussed below. Less attention has been paid to the aggregate labour market consequences of direct environmental regulation, payments for ecosystem services and subsidies to green research and development, although microeconomic studies of the impact of environmental policies on labour productivity and competitiveness have been undertaken (Dechezleprêtre and Sato (2014) on competitiveness studies and Koźluk and Zipperer (2013) on productivity studies). Green investment programmes and subsidies for green activities have generally been regarded as having a positive impact on employment, with some reservations about crowding out jobs elsewhere and destroying jobs in polluting sectors. Environmental taxes and regulation have generally been regarded as potentially harmful for employment unless governments take countervailing measures (for example using environmental tax revenues to reduce payroll taxes).

Meta-studies of the job potential of renewable energy

Starting with the employment impacts of green investment, a number of estimates have been made. 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 labour requirements of particular technologies ('bottom up' estimates, using simple spreadsheet-based models of job creation in conjunction with estimates drawn from engineering studies of specific plant and equipment embodying the technologies). An important issue is the timing and duration of job creation. There is an important distinction between construction, manufacture and installation, where jobs may be relatively short-lived, and ongoing operation, maintenance and fuel processing, where the duration 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 into account, for example, 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 a set of well-known criticisms of input-output models:

- They do not allow for changes in input-output coefficients over time – these are likely to be brought about, for example, by relative price changes, import substitution, changing tastes and technological progress.
- They are often out-of-date, compared for example with National Income Accounts.
- They depend on industrial classifications that do not distinguish some of the key sectors of interest.
- They do not take proper account of supply constraints.
- They are highly aggregated.

The meta-studies by Kammen and his associates attempt to derive standardised 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 total employment in the United States. 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.

Problems with metrics

Dalton and Lewis (2011) examine the metrics used to assess the job creation potential of renewable energy technologies to the economy, in particular the use of jobs per megawatt of capacity installed (jobs/MW), and assesses the reliability of their use, focusing on the wind industry and Ireland. Other industries examined are PV solar, wave, biogas and geothermal, as well conventional thermal industries. They show that use of jobs/MW installed in one year is an unreliable metric, as ratios are sensitive to the total installed MW in the year of the study. The authors argue that jobs/cumulative MW may be a more reliable metric. But they note that it is often difficult to ascertain which metric type has been used in a particular study or what method has been used to derive the statistic. The distinction drawn between 'direct' and 'indirect' jobs is often unclear, as is the treatment of jobs associated with imports and exports.

Lambert and Silva also discuss some of the problems of determining the employment effects of renewable energy in electricity production. They emphasise the big differences between the number of jobs created in the stages of technical development, installation, and operation and maintenance, which may lie behind the large variation in national estimates. According to Blanco and Rodrigues (2009), the estimated number of direct jobs recently created per megawatt of wind capacity installed varied from 0.76 in Austria to 6.97 in Belgium. Lambert and Silva note the wide variation in estimates for specific technologies and across technologies, finding that jobs per gigawatt hour per year (adjusted for capacity utilisation) range from 0.08 for wind in the authors' 'low employment' case to 1.21 for solar PV in the authors' standard case (compared with coal at 0.12).

Perhaps more important, Lambert and Silva emphasise that a more appropriate metric may be jobs divided by levellised total costs. After all, a high potential in terms of jobs per megawatt of capacity is of little help if the capacity concerned is expensive. Policy-makers want to know how many jobs they will generate from a given amount of spending not a given amount of capacity created. Unit costs of capacity are likely to rise if the productivity of renewables installations is lower than that of fossil fuelled installations. However, it turns out that the authors' rank ordering is little affected if the metric of jobs per unit of levellised total costs is used. Solar PV still looks as if it would be the most jobs-intensive per dollar of levellised costs in projections for 2016 and it is still difficult to determine whether wind and biomass will be more or less jobs-intensive per dollar than coal and natural gas.

Some researchers have attempted to extend estimates to 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 towards the total of those created by green policies, even if they are in sectors with no obvious relationship to environmental objectives (for example tobacco processing, where employment would apparently benefit if a carbon dioxide cap-and-trade scheme were implemented in the United States, according to Goettle and Fawcett (2009)) or only a secondary relationship (for example construction). One should still subtract jobs destroyed in sectors disadvantaged by green policies (for example coal mining) if one is trying to evaluate the overall labour 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 the hypothetical packages are expected to destroy jobs because of the Keynesian unemployment[4] assumed to exist when each package is implemented. Pollin et al. (2008) is a good example of this type of study, utilising an estimate of the macroeconomic multiplier effect of additional direct fiscal spending to calculate induced employment creation. It raises a question, however, about the merits of different types of spending to create jobs, given that in this Keynesian framework, other types of spending might generate more jobs than would green investment.

This discussion suggests that much greater clarity is needed about the methods and definitions used in estimates of job creation. Some standardisation would be desirable.

The importance of the time horizon assumed

Another approach considers different time horizons. The more distant the time horizon, the easier it will be to adjust the decisions made by firms before the horizon is reached. Fankhauser et al. (2008) consider:

- A short-term effect, when jobs are lost in sectors directly and adversely affected by new climate change policies and new ones are created in replacement industries. They label this 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. They call these the higher-order, economy-wide effects of climate policy. This corresponds to indirect effects and at least some induced effects.

4 The term 'Keynesian unemployment' is used as shorthand for involuntary unemployment due to inadequate aggregate demand (as opposed to frictional unemployment as workers who have lost their jobs in declining firms and sectors search for new jobs in a dynamic labour market). The persistence and, indeed, existence of Keynesian unemployment is contested within the economics profession.

- A long-term effect, when innovation and the development of new technologies create opportunities for investment and growth. They call this the dynamic effect of climate policy, a benign induced effect that has had less attention in the literature. Firms may be prepared to invest in innovative products and processes, for example in low-carbon energy supply, and put up with temporarily high labour requirements associated with early vintages of new technologies. This is more likely if new markets are created and if governments have taken steps to stimulate environmentally friendly inventions and innovation, and correct the market and government failures afflicting research and development. But learning by doing usually helps to increase labour productivity, so the positive impact of new technology and new green goods and services on jobs may be attenuated over time.

Ho et al. (2008) take a similar approach in their study of the impact of carbon price policies on industry in the United States, 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 due to the carbon price, but, in the longer term, gains in other industries would fully offset those losses.

General equilibrium modelling

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 modelling – that is, an approach that takes account of induced responses across the economy as a whole to changes in relative prices and wages. 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 price and wage adjustment, so that there is no involuntary unemployment. In such models, implementing carbon pricing will tend to redistribute jobs to low-carbon activities and reduce overall labour supply at any given level of wages paid by firms, because the higher relative price of carbon-intensive goods and services reduces what the wage is worth to workers (i.e. the real wage of labour falls), encouraging people to work less or not at all. The wages that firms pay may then increase as a result of competition among employers because labour demand would otherwise exceed labour supply, but in equilibrium, employment and real consumption wages are lower after the carbon price is imposed. The models treat employment costs as a social cost at the margin, not a social benefit, an important point often missing in green jobs studies. Workers have to be paid more if they are to be persuaded to give up their leisure time.

According to this framework, there can be net job destruction, depending on what is done with the revenues from carbon pricing – distributed as lump sum payments to households, used to lower taxes on labour or capital, spent on public investment or used to pay down government debt. In a study by Goettle and Fawcett (2009) of the potential implications of a cap-and-trade system for the United States, for example, there are significant reductions in labour input in 29 out of 35 industries (if there is no revenue recycling, i.e. revenues are used to reduce the public debt and this does not stimulate consumption). Frondel et al. (2010), adopting this perspective, argue that German renewable energy policy may have created a substantial number of jobs in the renewable energy sector but that this statistic is not a good measure of success. If one were to take proper account of jobs destroyed in fossil fuel-based electricity production, the loss of purchasing power on the part of electricity consumers and lower investment outside the renewables sector, Frondel et al. suspect that the employment consequences would look much less attractive. Much depends on prospective trade performance: will Germany generate strong net exports from investment in renewable energy?

More sophisticated treatments allow for involuntary unemployment and job-worker matching frictions. Böhringer et al. (2012) apply a computable general equilibrium model to assess the labour market impacts of the feed-in tariff policy used by the Government of Ontario to stimulate renewable energy production. The tariffs are paid by electricity consumers and received by the renewables producers (so there is no tax revenue to redistribute). They find that although the policy is successful at increasing employment in the green sectors of the economy, the policy is also likely to increase the rate of unemployment in the province and to reduce overall labour force participation. According to the authors, the current Ontario feed-in tariff (FiT) policy is likely to generate roughly 12,400 new jobs in the renewable energy generation and manufacturing sectors. But each new job created by the policy in green sectors of the economy is likely to cause the loss of nearly two jobs in other sectors of the economy. Electricity prices go up, real wages are reduced, labour supply is discouraged, and jobs are lost to other provinces. They therefore conclude that policies designed to promote renewable energy should be promoted only for the sake of their environmental impacts, not for their labour market effects.

However, although their modelling allows for equilibrium unemployment due to labour market frictions, it does not allow for involuntary unemployment due to inadequate aggregate demand. If the latter existed in the relevant time period, firms and workers would be constrained in part by the demand for their services, not just by input costs and real wages, and the overall effect on jobs would depend partly on the impact of the FiT on aggregate demand (for example via different saving propensities of electricity consumers and renewables producers).

There still remains much debate about how best to characterise business cycles and labour market adjustment. Are workers always on their labour supply curves, as in standard real business cycle theory? What are the dynamics of job creation 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? 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 green investment would have (as opposed to a first-best policy of removing the offending rigidity). All of these questions are relevant to investigating the likely labour market consequences of green policy initiatives ranging from carbon pricing to changes in government subsidies to renewable energy to deficit-financed green infrastructure investment.

Babiker and Eckaus (2007) illustrate the importance of the macroeconomic framework applied when estimates of employment changes are made. They show how, in the presence of real wage rigidities or barriers to the sectoral reallocation of labour, climate policy (carbon prices) could increase unemployment, particularly where employment in fossil fuel sectors is large to begin with. Overall labour 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, 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 labour supply – employment will fall by less or even increase.

Hence knowing the best way to model how the aggregate labour market works – and, indeed, how the macro-economy as a whole works – is crucial for a proper assessment of changes in direct and indirect labour demand, and first-round and induced employment effects. There are important differences across types of economy due to different industry structures, labour market institutions and endowments. Probably the most useful concepts 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 labour market impacts not only of carbon pricing but also of other efforts to correct market failures contributing to carbon emissions, such as research and development subsidies to correct under-supply of innovations and public spending financed by debt to improve the provision of energy infrastructure. Projections of the employment consequences of climate change policies also need to take into account how other policies, especially budgetary ones, are adjusted at the same time.

4. Estimates of potential green job creation in different countries

Surveys of individual studies

A number of surveys have collated estimates of 'job creation potential' in green activities, variously defined, and have discussed their methodological strengths and weaknesses, including GHK (2009), Fankhauser et al. (2008), the Global Climate Network (GCN) (2009) and Bacon and Kojima (2011). Kammen at al. (2004), Wei et al. (2010), and Bacon and Kojima (2011) 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. GHK (2009) provides a useful categorisation of differences among studies:

- Differences in the spatial scope of investigation, for example global or country-specific
- Differences in the size and number of sectors considered
- Gross and net effects
- Inclusion/exclusion of whole value-chain effects
- Differing assumptions concerning economic growth and the effect of existing business as usual policies.

Wei et al. (2010) is illustrative of the general thrust of the literature. They conclude that the renewable energy and low-carbon sectors generate more jobs per unit of energy delivered than the fossil fuel-based sector, with solar photovoltaics (PV) creating the most jobs per unit of electricity output. The authors estimate that two measures, cutting the annual rate of increase in electricity generation in half (by improving energy efficiency) and generating 30 per cent of electricity from renewables, each could generate about 2 million job-years in the United States by 2030.[5]

Pollin et al. (2008) similarly argue that a $100 billion fiscal stimulus in the United States 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, when comparing strategies, indirect employment creation is often larger than direct job creation given the assumptions about supply chains and fiscal multipliers, reassuring the 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 supposedly more labour-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). Lambert and Silva (2012) cast some doubt on the reliability of this assumption, as noted above.

5 A job-year is simply a measure of employment over time; 4 million job-years could comprise, for example, 4 million jobs, each of which lasts for only a year, or 200,000 jobs, each of which lasts for 20 years.

GHK tabulate results from 32 different studies; most used data from the European Union or specific member states, seven used data from the United States and four used global data. It is striking that no studies explicitly covered developing countries. 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. As discussed below, studies from developed countries may not be good guides to the employment creation potential in developing countries, because of differences in relative factor prices, endowments and labour market characteristics. Five of the 15 studies covered by Wei et al., 14 of the 32 studies covered by GHK and 25 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. Many of the findings give the impression 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 labour 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. Arguments might equally be advanced for many other employment generation policies, such as recruiting teachers and health workers or embarking on large-scale construction projects.

Important caveats

Fankhauser et al. (2008) note two important caveats that apply to estimates such as those of Pollin et al. (2008). First, higher labour intensity per unit of energy capacity created implies lower labour productivity than in conventional energy production. Renewable energy may be more expensive and less efficient than conventional sources, with high capital as well as labour requirements, shorter-lived plant and more intermittent energy production. Some studies of potential employment creation ignore the question of whether it would be profitable for the private sector to adopt the programmes considered. Studies rarely take into account the macroeconomic consequences of higher real energy prices (or higher energy subsidies) on the overall price level, labour supply, labour productivity and taxation.

Second, labour 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.

As an example of possible macroeconomic ramifications, consider investment. Converting countries' energy sectors to low-carbon technologies is likely to require increased investment, which could be undertaken by the government or the private sector, or some mixture of the two. Studies suggest that incremental investment of the order of US$ 500 billion per year might be required (UNFCCC, 2007; IEA, 2008; McKinsey & Company, 2009; McCollum et al., 2013). The extra investment would generate a net increase in jobs starting from a position of Keynesian unemployment, but would have to be paid for. As McCollum et al. (2014) note, "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." One major constraint on the supply of

financial capital at the moment is the desire of many developed country governments to reduce the size of their budget deficits relative to GDP. Without the finance, the job creation will not be forthcoming.

Another shortcoming is that some studies of potential employment creation 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). In the environmental area, building insulation retrofits, reforestation and land-use changes are likely to be more labour-intensive.

The prospects for employment creation in developing countries

These caveats help to explain why Strand and Toman (2010) express some scepticism about proposals for a green fiscal stimulus, particularly in developing countries. Road building, for example, is relatively labour 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 emphasise short-run employment creation, because of the lead times necessary for replacing plants, buildings and equipment in the energy sector.

Overall, Strand and Toman conclude that there are likely to be trade-offs for employment generation. Programmes that yield larger employment effects tend to lead to more employment gains for largely lower-skilled workers, so 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 labour intensive. The argument for investing in initially labour-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.

Dercon (2012) also sees a tension between employment-augmenting poverty alleviation and green growth. He regards high labour intensity, declining shares of agriculture in gross domestic product and employment, migration and urbanisation as essential features of poverty-reducing growth. But his review of various green growth policy proposals in the areas of agriculture, trade, technology, infrastructure and urban development suggests that they are not always consistent with the requirements of poverty-sensitive growth. In other words, climate change mitigation policies and other green growth initiatives cannot be relied upon to generate enough of the right sort of jobs in the right places to be very effective in poverty reduction. Instead, they may well cause a slow-down in the effectiveness of growth in reducing poverty. The main lesson is that trade-offs are bound to exist. They increase the social costs of green growth and should be explicitly addressed.

Strand and Toman (2010) also review the literature on green fiscal stimuli and job creation specifically in developing countries, noting that the evidence is scant and patchy. 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 labour intensive, generating nearly eight times as many jobs per dollar as the least labour-intensive green activity, '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 drawing on

evidence from the United States and Europe may lead policy-makers to overlook the opportunities for employment creation from changes in land management and agriculture, especially in developing countries, where these economic sectors are relatively more important. They are, however, sectors with low labour productivity – the very characteristic that makes them attractive for job creation. If green growth policies slow down the reallocation of employment towards higher labour productivity industries, they may not be the best way to promote poverty reduction and desirable long-run structural change. The key challenge is to understand how in a particular setting increased government spending on green objectives and increased environmental taxation is likely to affect wage-setting, migration and unemployment in practice.

Schwartz et al. (2009) consider direct employment effects of fiscal stimulus projects in three Latin American countries, Honduras, Brazil and Peru. Again, the variation in jobs created per US 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 labour 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 labour 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 renewable energy 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 internalise externalities, and (ii) an Energy [R]evolution scenario designed to reduce South African emissions by 60 per cent by 2050 (compared with 2005). The authors estimate that the Energy [R]evolution scenario creates 27 per cent more jobs than the IEA reference scenario and 5 per cent more than the GWC scenario. Macroeconomic feedbacks are not analysed; 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 estimates 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 industrialised countries, Upadhyay and Pahuja 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 labour 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 labour, 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 emphasises 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 labour intensive than traditional energy sources. Once again, the question of the labour productivity and unit 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 hydroelectricity 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 utilisation 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 (2009) concluded that most of the policies analysed in the contributing studies generate additional direct employment. Several environmentally beneficial activities in developing countries, including renewable energy but especially changes in land use, could be considerably more labour intensive than traditional fossil fuel-based energy supply. A major caveat with the studies is that little attention is paid to jobs displaced in high-carbon and other environmentally harmful activities or to macroeconomic constraints and the possibility of crowding out jobs.

5. Modelling labour markets in developing countries

If macroeconomic constraints are potentially important, how are they to be characterised? It has long been recognised that the standard simple neoclassical or Keynesian models may not adequately represent labour markets in developing countries.[6] For example, the 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 green jobs are likely to displace at least as many jobs elsewhere in the economy, may not apply because the assumptions on which it is based – notably, that employment is determined in competitive, flexible-wage markets – do not hold.

This issue is important for evaluating the labour market implications of green growth policies in developing countries. In a surplus labour 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 advanced 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, such as India (Harris and Todaro, 1970; Fields, 1975; Mazumdar, 1976). Productivity increases induced by higher wages (efficiency wage theories), wage regulation in formal employment and the payment of family labour according to average rather than marginal productivity are among the mechanisms that warrant a more sophisticated analysis of labour markets.

Babiker and Eckaus (2007) explore the impact of constraints on real wage adjustment and on inter-industry flows of labour in different regions of the world in one of the relatively rare efforts to introduce more realistic labour market characteristics in a study of the impact of environmental taxation. They find that China and India might be the countries most adversely affected by the structural changes induced by carbon pricing (in terms of output losses and sectoral misallocation of labour), largely because these are the regions that need most reallocation of labour in response to better environmental policies.

It would be useful to consider the implications of various models on how the labour market functions that are more specific to developing countries (for example as reviewed by Behrman, 1999) for the employment and wage impacts associated with a shift towards green policies. Box 1 below outlines some recent research that takes a step in this direction. One particularly interesting finding is that how green policies – in this case, an energy or carbon tax – interact with income-support policies is important for the labour market outcome, with some unexpected implications for the impact of a carbon tax in different sectors of an economy.

6 The applicability of these two canonical models in advanced industrial economies has also been questioned, as reflected in the literature on frictional and search unemployment and on aggregate wage-setting.

Box 1: Carbon taxes and labour markets in developing countries

Most studies that have analysed the effects of environmental tax reforms on labour markets are studies of developed countries. Extrapolation of these studies to the case of developing countries could be misleading. Incorporating the special features of developing countries in the analysis of tax incidence, in particular the incidence of a carbon tax, can produce different results.

Kuralbayeva (2013) starts to take account of this issue by analysing the effects of green tax reform in the context of an archetypal middle-income developing country, which contains a large informal sector and experiences rural-urban migration. The economy is comprised of three sectors: urban formal, urban informal and agricultural sectors. There is scope for migration and workers can seek work in any of the three sectors. In the informal sector, workers are assumed to be self-employed in low-productivity, labour-intensive tasks.

The model economy features labour market frictions, so it is costly for firms and workers to find partners with whom they can produce output. It is also assumed that all workers in the informal sector search for jobs in the formal sector with higher returns. Not all of them can find such jobs, however, so some people remain in the informal sector and can be thought of as under- or unemployed. The model also allows for different institutional arrangements concerning the taxation of unemployment benefits and different assumptions about how income from informal activities varies.

The government budget is balanced every period ('fiscal neutrality') but the size of the budget can vary. The model is run under two different assumptions about the level of public expenditure: (i) public expenditure is a fixed share of GDP (so the provision of public goods changes with any changes in GDP stemming from implementation of green tax reform); and (ii) the provision of public goods is constant. Tax revenue includes receipts from taxing energy and labour in the formal sector. Public expenditure comprises spending on the provision of public goods and transfers to the 'unemployed' (informal sector workers). Revenues generated from higher taxation of energy are used to cut taxes on labour and provide 'unemployment' benefits.

This model of the archetypal economy is calibrated to correspond broadly to the case of Mexico. Key results of the analysis are as follows:

- Green tax reform can reduce unemployment when the tax burden is shifted on to the informal sector and rural workers. The key difference from developed country studies is that the incidence of the carbon tax in the developing economy is partly shifted to the rural sector through rural-urban migration effects. Thus, rural workers, although they do not directly pay the tax, bear part of the burden through reduced wages. Yet the energy tax appears to be progressive when examining the impacts on the urban areas.

- Green tax policies that raise the tax burden on the informal sector improve labour market incentives – search efforts by these 'unemployed' workers increase. The formal sector, however, experiences higher employee turnover than before.

- Even if energy tax revenues are used to cut distortionary taxes on labour, and the level of provision of public goods is fixed, the government is unable to cut taxes on labour sufficiently to compensate for the adverse effect of higher energy taxes on private sector incomes, in particular, the income of those who receive welfare benefits.

- By lowering spending on public goods, it is possible to reduce the overall tax burden in the economy and reduce the adverse effect of higher energy taxation on incomes in the private sector, in particular, the income of the unemployed and workers in rural areas. The overall effect on welfare depends on who benefits from the provision of the public good.

Box 1: Carbon taxes and labour markets in developing countries *(continued)*

These results suggest that:

- The labour market consequences of a carbon tax can spread beyond the sector that is subject to the tax and can be counter-intuitive.
- The environmental tax's interaction with social benefits and the job-search behaviour of workers are both crucial.
- The labour market effects of environmental tax reforms can be improved if appropriate complementary policies are applied.

Although these conclusions arise from a model calibrated to represent an archetypal middle-income developing country, they have much wider applicability when expressed in this general form.

Green policies might also induce inward flows of capital (for example 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 along these lines. For example, adaptation to climate change in rural areas could be modelled 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 modelled as reducing productivity throughout the economy.

Understanding better the interaction of business cycles and labour markets in developing countries would help to establish the scope for green fiscal stimuli to counter increases in involuntary unemployment and underemployment. 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 are often more of a problem (especially in countries dependent on international commodity trade) than in developed economies (Kraay and Ventura, 1998; Otero, 2000). Some have argued that 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). If so, the scope for green fiscal stimuli may have been overlooked.

The key point to draw from this section is that the overall effects of green policies on employment depend on the characteristics of the economy's labour markets and the precise nature of the policy interventions, including their funding, not just the input requirements of rival energy technologies.

6. Heterogeneity of developing countries

It is argued above that it is important to recognise that developing countries face different circumstances than developed ones. But there is a lot of variation across developing countries as well, particularly with regard to how easily the transition to low-carbon growth can be managed. 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 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 per cent of the growth in electricity capacity based on renewable energy in the rest of Africa by 2020 will be supplied by South African manufacturers, and by 2030, 30 per cent. 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 favour the development of this industry (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. For these countries, more labour will probably need to be reallocated from current greenhouse gas intensive activities, either by switching technologies within an industry or by moving labour between industry sectors. Given the importance of carbon dioxide emissions from energy production, energy-intensive economies will comprise a large part of this group.

Endowments of fossil fuels combined with industrial development strategies that have favoured carbon-intensive industry make a transition to low-carbon much more challenging (EBRD, 2011). Countries such as Kazakhstan and Mongolia with a much larger-than-average proportion of the labour 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 labour to other sectors emphasized by Babiker and Eckaus (2007).

Similarly, some lower-income countries appear to produce relatively high levels of methane from agriculture per unit of GDP, 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.

7. Conclusions

One potential benefit of a transition to green growth is the creation of jobs. The generation of green jobs has been one of the more popular promises of climate change and other environmental policies. However, there are different ways of assessing the employment consequences of such policies.

One approach is to focus on categorising existing jobs that help provide environmental and resource management services. European Union members in particular are making progress on this front. There is some evidence that such jobs are growing in number – a bit faster than employment as a whole – but from a low base. But with climate change mitigation measures strengthening around the world, it is important for national statistical agencies to get a better grasp on what is happening to employment (and GDP) in these industry sectors, so that they can alert policy-makers to the extent of structural change that such policies are inducing.

Another approach is to count the jobs created and destroyed directly when firms adopt low-carbon technologies and switch to lower carbon inputs, regardless of the primary outputs of the firms. Such an approach is also helpful in assessing the scale of structural change required by the transition to green growth. As Deschênes (2013) has stressed, this requires much better data and more rigorous methods than have generally been applied. The collection of statistics on jobs in environmental sectors using an internationally agreed framework would be an important step in this direction. However, the challenge of measuring the impact of green policies in actual labour markets, rather than in very simplified models of labour markets, would remain.

From the perspective of national policy-makers, the net change in total employment (and average job quality) across the economy as a result of green policies is at least as important as the direct gross change in employment in environmental sectors. Much of the green jobs literature focuses on the most direct impacts of policies on employment, with some attention to indirect and induced job creation and to the destruction of 'brown jobs' in polluting industries. However, the consequences for labour markets of green growth policies, for example via macroeconomic adjustments to labour productivity and the costs of employment, are often overlooked. These consequences can vary sharply depending on the policy instrument used, the macroeconomic circumstances of a country and how its labour markets function. The short-term consequences after an adverse shock to aggregate demand are likely to differ from the long-term consequences when relative prices and investment have had time to adjust. Problems of involuntary unemployment, low wages and inadequate training cannot be solved primarily by environmental policies. However, to the extent that green growth policies successfully correct market and government failures, they have the potential to improve labour market outcomes.

In the light of these observations, it would be helpful for policy-makers to do the following:

- Accelerate international efforts to establish common statistical standards for measuring the number of existing green jobs, building on the frameworks provided by the UN System for Integrated Environmental-Economic Accounting and the International Conference of Labour Statisticians (ICLS) recommendations for classifying jobs.

- Restore the momentum behind the compilation of national green jobs statistics in countries where it has slackened, notably the United States and United Kingdom.

- Consider ways in which international agencies such as Eurostat and the OECD, and countries that already report regularly, can help developing countries improve their statistics on green jobs.

- Assess regularly – using improved data –the pace at which the demand for workers in environmental and resource management services is changing, comparing this with the normal degree of flux and change in labour markets.

- Assess the likely labour market impacts of economy-wide green growth using a macroeconomic framework, given that climate change and other green growth policies are likely eventually to constitute a large, non-marginal change in the policy environment for firms and households.

- Develop strategies for coping with employment losses in the sectors that will suffer from green growth policies, remembering that this may include sectors hit by higher real prices for currently carbon-intensive inputs (such as electricity, aluminium and cement).

There are also implications for research priorities in this area, which include:

1) More careful *ex post* comparisons of the employment created by investments embodying clean and dirty technologies to produce similar outputs

2) The combination of microeconomic evidence about key labour market parameters with more realistic models of how labour markets actually work at the aggregate level, bearing in mind that there are important differences across countries at different levels of development and subject to different macroeconomic pressures. Key differences (many of which have so far been neglected in this context) include:

- The reasons for existing unemployment

- How labour market institutions affect wage setting and the provision of training

- The ease with which workers can find new jobs in different sectors and locations

- The competitiveness of labour markets

- The reach and terms of public employment promotion, taxation and social benefits.

References

Asian Development Bank (ADB), Asian Development Bank Institute, 2013. *Low-carbon green growth in Asia: Policies and practice*. Manila & Tokyo: Asian Development Bank, Asian Development Bank Institute.

Alvarez, G.C., Jara, R.M., Juliá, J.R.R., Bielsa, J.I.G., 2010. Study of the effects on employment of public aid to renewable energy sources. *Procesos de Mercado: Revista Europea de Economía Política,* 7(1), Primavera 2010, pp.13-70.

Babiker, M.H., Eckaus, R.S., 2007. Unemployment effects of climate policy. *Environmental Science & Policy*, 10, pp.600-609.

Bacon, R., Kojima, M., 2011. *Issues in estimating the employment generated by energy sector activities, Background paper for the World Bank Group energy sector strategy*. Washington DC: Sustainable Energy Department, World Bank.

Barbier, E.B., 2009. *A global green New Deal*. Geneva: United Nations Environment Programme.

Behrman, J., 1999. Labor markets in developing countries. In J. Ashenfelter, D. Card (eds.) 1999, *Handbook of Labor Economics*, Vol. 3, Oxford: Elsevier, pp.2859-2939.

Blanco, M.I., Rodrigues, G., 2009. Employment in the wind energy sector: An EU study. *Energy Policy*, 37, pp.2847-2857.

Böhringer, C., Rivers, N.J., Rutherford, T.F., and Wigle, R., 2012. Green jobs and renewable electricity policies: Employment impacts of Ontario's feed-in tariff. *The B.E. Journal of Economic Analysis & Policy*, 12(1), pp.1-38.

Bowen, A., 2012. *"Green" Growth, "Green" Jobs and Labor Markets, Policy Research Working Paper No. 5990*. Washington DC: World Bank.

Dalton, G.J., Lewis, T., 2011. Metrics for measuring job creation by renewable energy technologies, using Ireland as a case study. *Renewable and Sustainable Energy Reviews*, 15, pp.2123–2133.

Dechezleprêtre, A., Sato, M., 2014. *The impacts of environmental regulations on competitiveness. Grantham Research Institute Policy Brief*. London: London School of Economics and Political Science.

Dercon, S., 2012. *Is green growth good for the poor? Policy Research Working Paper No. 6231*. Washington DC: World Bank.

Deschênes, O., 2013. *Green jobs, Policy Paper No. 62*. Bonn: Institute for the Study of Labor.

Dutt, A.K., 2007. Heterodox development economics and the role of aggregate demand. In: Glasgow University, *International Conference on Development Economics, Policies and institutions for growth and development: Is there a 'heterodox' view?* Glasgow, United Kingdom, 26-27 June 2007. Glasgow: University of Glasgow.

Ecorys, 2012. *The number of jobs dependent on the environment and resource efficiency improvements: Final report*. Rotterdam: Ecorys.

European Bank for Reconstruction and Development (EBRD), 2011. *The Low carbon transition report.* London: European Bank for Reconstruction and Development.

European Commission, 2007. *Facts and figures: Links between EU's economy and environment.* Luxembourg: Office for Official Publications of the European Communities.

Eurostat, 2009. The environmental goods and services sector: a data collection handbook, Eurostat, European Commission, Brussels

Fankhauser, S., Sehlleier, F., Stern, N., 2008. Climate change, innovation and jobs. *Climate Policy*, 8, pp.421-429.

Fields, G.S., 1975. Rural-urban migration, urban unemployment and underemployment, and job search activity in LACS. *Journal of Development Economics*, 2, pp.165-187.

Figueres, C, Ryder, G., 2014. *How to create jobs by tackling climate change.* [online] Available at: https://www.project-syndicate.org/commentary/christiana-figueres-and-guy-ryder-emphasize-the-job-creating-potential-of-action-to-mitigate-climate-change

Frondel, M., Ritter, N., Schmidt, C.M., Vance, C., 2010. Economic impacts from the promotion of renewable energy technologies; the German experience. *Energy Policy*, 38, pp.4048-4056.

Fullerton, D., Metcalf, G.E., 1997. *Environmental taxes and the double-dividend hypothesis: did you really expect something for nothing? NBER Working Paper No. 6199.* Cambridge, MA: National Bureau of Economic Research.

GHK, 2009. *The impacts of climate change on European employment and skills in the short to medium term: A review of the literature, Final Report to the European Commission Directorate for Employment, Social Affairs and Inclusion Restructuring Forum*, Vol. 2. London: GHK International

Global Climate Network, 2009. *Low-carbon jobs in an interconnected world, Global Carbon Network discussion paper No. 3*. London: Global Climate Network.

Goettle, R.J., Fawcett, A.A., 2009. The structural effects of cap and trade climate policy. *Energy Economics*, 31, Special Supplement, 2, pp.244-253.

Greenpeace, European Renewable Energy Council, 2011. *The advanced energy [R]evolution: A sustainable energy outlook for South Africa*. Brussels: Greenpeace, European Renewable Energy Council.

Harris, J.R., Todaro, M.P., 1970. Migration, unemployment, and development. *American Economic Review*, 60, pp.126-142.

Ho, M.S., Morgenstern, R., Shih, J-S., 2008. *Impact of carbon price policies on U.S. industry, DP 08-37*. Washington DC: Resources for the Future.

Hughes, G., 2011. *The myth of green jobs, Report No.3*. London: The Global Warming Foundation

International Conference of Labour Statisticians (ICLS), 2013. *Report of the 19th Int ICLS/19/2013/3*. Geneva: International Labour Organization.

International Energy Agency (IEA), 2008. *World Energy Outlook 2008*. Paris: IEA.

International Labour Organization (ILO), 2013. *Sustainable development, decent work and green jobs. Report of the 102nd session of the International Labour Conference*. Geneva: ILO.

International Labour Organization (ILO), 2015. *World employment and social outlook – Trends 2015*. Geneva: ILO.

International Renewable Energy Agency (IREA), 2014. *Renewable energy and jobs – Annual review 2014*. Abu Dhabi: IREA.

Kammen, D.M., Kapadia, K., Fripp, M., 2004. Putting renewables to work: how many jobs can the clean energy industry generate? *Report of the Renewable and Appropriate Energy Laboratory*. Berkley, CA: University of California, Berkeley (corrected January 2006).

Kojima, M., Johnson, T., 2005. *Potential for biofuels for transport in developing countries, Energy Sector Management Assistance Programme*. Washington DC: The World Bank.

Koźluk, T., Zipperer, V., 2013. *Environmental policies and productivity growth – a critical review of empirical findings, Economics Department Working Paper No. 1096*. Paris: OECD.

Kraay, A., Servén, L., 2008. *Fiscal policy responses to the current financial crisis: Issues for developing countries, Research Brief*. Washington DC: World Bank.

Kraay, A., Ventura, J., 1998. *Comparative advantage and the cross-section of business cycles, Policy Research Working Paper 1948*. Washington DC: World Bank.

Kuralbayeva, K., 2013. *Effects of carbon taxes in an economy with large informal sector and rural-urban migration, Grantham Research Institute Working Paper No. 139*. London: London School of Economics and Political Science.

Lambert, R.J., Silva, P.P., 2012. The challenges of determining the employment effects of renewable energy. *Renewable and Sustainable Energy Reviews,* 16, pp.4667-4674.

Lewis, W.A., 1954. Economic development with unlimited supplies of labour, *Manchester School of Economic and Social Studies,* 22, pp.139-191.

Livesey, D., 2010. *Measuring the environmental goods and services sector, Economic & Labour Market Review*. London: Office of National Statistics.

Martinez-Fernandez, C., Hinojosa, C., Miranda, G., 2010. *Greening Jobs and Skills: Labour Market Implications of Addressing Climate Change, OECD Local Economic and Employment Development (LEED) Working Papers, 2010/2*. Paris: Organisation for Economic Co-operation and Development.

Mazumdar, D., 1976. The rural-urban wage gap, migration, and the shadow wage. *Oxford Economic Papers,* 28(3), pp.406-25.

McKinsey & Company, 2009. *Pathways to a low-carbon economy*. New York: McKinsey & Company.

McCollum, D., Nagai, Y., Riahi, K., Marangoni, G., Calvin, K., Pietzcker, R., van Vliet, J., van der Zwaan, R., 2013. Energy Investments Under Climate Policy: A Comparison of Global Models, *Climate Change Economics,* 4(4).

Michaels, R., Murphy, R.P., 2009. *Green jobs: fact or fiction?* Houston: Institute for Energy Research.

Morriss, A.P., Bogart, W.T., Dorchak, A., Meiners, R.E., 2009. *Green jobs myths, University of Illinois Law & Economics Research Paper No. LE09-001 and Case Western Reserve University Research Paper Series No. 09-15*. Champaign, IL: University of Illinois, Case Western Reserve University.

Organisation for Economic Co-operation and Development (OECD), 1999. *The environmental goods and services industry: Manual for data collection and analysis.* Paris: Organisation for Economic Co-operation and Development.

Organisation for Economic Co-operation and Development (OECD), 2011. *Towards green growth*. Paris: OECD.

Otero, J.G., 2000. Coffee, economic fluctuations and stabilisation: an intertemporal disequilibrium model with capital market imperfections. *Journal of Development Economics,* 62, pp.105–129.

Pew, 2009. *The clean energy economy: Repowering jobs, businesses and investments in America*. Washington DC and Philadelphia: The Pew Charitable Trusts.

Pissarides, C.A., 2009. *Labour market adjustment*. Cambridge: Cambridge University Press.

Pollin, R., Garrett-Peltier, H., Heintz, J., Scharber, H., 2008. *Green recovery: a program to create good jobs and start building a low-carbon economy*. Washington DC: Political Economy Research Institute, Center for American Progress.

Rutovitz, J., 2010. *South African energy sector jobs to 2030, prepared for Greenpeace Africa by the Institute for Sustainable Futures*. Sydney: University of Technology.

Rutovitz, J., Atherton, A., 2009. *Energy sector jobs to 2030: a global analysis, prepared for Greenpeace International by the Institute for Sustainable Futures*. Sydney: University of Technology.

Sartzetakis, E.F., Tsigaris, P.D., 2007. *Uncertainty and the double dividend hypothesis, Nota di Lavoro 99.2007*. Milan: Fondazione Eni Enrico Mattei.

Schwartz, J.Z., Andres, L.A., Draboiu, G., 2009. *Crisis in Latin America. Infrastructure Investment, Employment and the Expectations of Stimulus, Policy Research Working Paper WPS 5009*. Washington DC: World Bank.

Strand, J, Toman, M., 2010. *"Green Stimulus," Economic Recovery, and Long-Term Sustainable Development, World Bank Policy Research Working Paper No. 5163,* Washington DC: World Bank.

United Nations Environmental Programme (UNEP), 2011. *Towards a green economy: pathways to sustainable development and poverty eradication – a synthesis for policy makers.* Geneva: United Nations Environmental Programme.

United Nations Environmental Programme (UNEP), 2014. *Measuring the environmental goods and services sector: Issues and challenges*. Geneva: United Nations Environmental Programme.

United Nations Environmental Programme, International Labour Organization, International Organisation of Employers, International Trades Union Confederation (UNEP/ILO/IOE/ITUC), 2008. *Green jobs: Towards decent work in a sustainable, low-carbon world*. Geneva: UNEP/ILO/IOE/ITUC.

United Nations Framework Convention on Climate Change (UNFCCC), 2007. *Investment and financial flows to address climate change*. Bonn: United Nations Framework Convention on Climate Change.

Upadhyay, H., Pahuja, N., 2010. *Low-carbon employment potential in India: A climate of opportunities, Centre for Global Climate Research TERI and Global Climate Framework Discussion Paper TERI/GCN – 2010:1*. New Delhi: The Energy and Resources Institute, Global Climate Network.

Wei, M., Patadia, S., Kammen, D., 2010. Putting renewables and energy efficiency to work: How many jobs can the clean energy industry generate in the US? *Energy Policy,* 38, pp.919–931.

World Bank, 2012. Inclusive green growth: *The pathway to sustainable development*. Washington DC: World Bank.

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