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Green Jobs

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ABSTRACT

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In recent years the prospect of 'green jobs' or 'green growth' policies have become increasingly prominent, proposed to solve both the environmental challenges associated with global climate change and the persistent unemployment problems observed in many industrialized countries. This short article begins by describing the conceptual, definitional, and measurement issues related to green jobs. I then review the existing evidence from the primarily simulation-based studies that attempt to assess the impact of green policies on employment. I draw two main conclusions from this exercise. First, my descriptive analysis of the U.S. Bureau of Labor Statistics data on green jobs highlights that green jobs currently represent a small share of overall employment in the U.S, and one that has seen relatively weak growth in the last decade. Second, due to the sizable heterogeneity in the scope and assumptions made in the existing simulation studies of the labor market impacts of green policies, it is difficult to make a definitive conclusion about their likely impact. More careful and detailed empirical research is needed to assess the job creation potential of green job policies.

JEL Classification: J08, J23, Q48

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Introduction

In recent years the prospect of 'green jobs' or 'green growth' policies have become increasingly prominent, proposed to solve both the environmental challenges associated with global climate change and the persistent unemployment problems observed in many industrialized countries. In the United States such proposals began in the Green Jobs Act of 2007 (as a component of the 2007 Energy Independence and Security Act) and continued in the American Recovery and Reinvestment Act of 2009. While the Green Jobs Act was never enacted as law, the American Recovery and Reinvestment Act of 2009 procured funding for green initiatives, primarily for energy efficiency and renewable energy investments, and for related R&D.

At the same time, similar policies were also proposed and implemented in many other countries, in many instances as part of broader stimulus packages. According to HSBC (2009), $430 billion (USD) in fiscal stimulus have been allocated globally to "climate change investment themes", with China and the United States being the two largest contributors. This corresponds to roughly 15% of global stimulus expenditures, with targeted investments primarily in low-emission transportation, grid expansion and efficiency, building energy efficiency, and renewable energy (especially in the U.S. for the latter).

The motivation for such targeted national investments is threefold: First they reflect a desire by governments to stimulate the production and development of less carbon-intensive energy sources in order to reduce emissions of carbon. Second, green policies clearly have an explicit objective of boosting employment. For example, employment in sectors such as construction is expected to grow as the demand for energy-efficient homes and buildings is expected to increase as a result of these policies. Third, green policies are implemented with the expectation that they will lead to spillovers, economies of scale, and comparative advantage in the development of green technologies, and in the production of green goods and services. Consequently, these policies should be evaluated with three corresponding criteria: (1) whether they lead (or will lead) to improvement in environmental quality; (2) whether they create long-term employment and earnings growth for workers in green sectors; and (3) whether they contribute to a sustained competitive edge through learning-by-doing effects in the relevant industries. Another important criterion for evaluating targeted green policies is whether they achieve their goals in an efficient manner, relative to alternative approaches.

While many green policies are still ongoing, it is crucial to begin examining the evidence regarding the impacts of such massive investments. This short essay will concentrate on the labor market impacts of green job policies. From a broader perspective, the question of whether or how green policies affect labor markets is hardly a new question. There is a long standing debate on the connection between environmental regulations and firm competitiveness, and ultimately employment. A major concern is that stricter environmental regulations lead to displacement of jobs, especially in energy-intensive and globally-trading industries, although the empirical evidence regarding the magnitude of those displacement effects is mixed (see e.g., Jaffe et al. 1995, Berman and Bui 2001, Greenstone 2002, Walker 2011).

The goal of this short article is threefold. First I describe a conceptual framework to evaluate the possible employment effects of green policies. Second, I discuss the various definitional and measurement issues related to green jobs, and present descriptive evidence for the United States, based on recent data from the U.S. Bureau of Labor Statistics (BLS). Third, I review the evidence from the existing studies that attempt to assess the impact of green policies on employment.[2] These studies are almost entirely based on simulation models as opposed to direct empirical analysis of labor market data. Further, the majority of these studies have been published in reports as opposed to peer-reviewed journals.[3] As a result there are substantial research gaps that need to be addressed in the coming years.

I draw two main conclusions from this exercise. First, my descriptive analysis of the U.S. BLS data on green jobs highlights that green jobs currently represent a small share of overall employment in the U.S. For instance, the service sector which accounts for half of total hours worked in the U.S. economy is not a green sector: only 2% of employment in that sector is labeled 'green' according to the U.S. BLS definition. Published estimates from other countries also indicate that green employment only accounts for 2-3% of aggregate employment. Further, between 2001 and 2010, the share of hours worked in the "greenest" sectors in the U.S. economy only accounted for one third of total hours worked, and if anything the trend over time shows a slightly declining share. This very simple descriptive evidence appears to invalidate the premise that green sectors grow faster than 'brown' sectors. This premise is one of the primary justifications motivating the use of green job policies as engines of job growth and as long-term drivers of sustainable economic growth (UNEP 2008). Thus more research needs to evaluate these claims with more rigorous empirical methods. Future research should also compare the net employment gain associated with a specific green job policy with the improvements in environmental quality it generates.

Second, due to the sizable heterogeneity in the scope and assumptions made in the existing simulation studies of the labor market impacts of green policies, it is difficult to make a definitive conclusion. This issue is only magnified by the fact that almost none of the existing studies have gone through the formal peer-review process associated with journal publications. Such process will help create and preserve continuity and progress across studies, and help streamline and homogenize the assumptions made in the simulation models. It will also better disseminate the results of this research to the economics profession. This will hopefully fuel an improved research agenda in the coming years.

In summary, much remains to be learned regarding the effect of green policies on employment creation, and whether these policies can be long-term determinants of sustainable economic

[2] Many of these studies also discuss possible green skills shortages associated with green growth policies. I do not address these considerations in this short article. See Bowen (2012) for a discussion of these issues.

[3] An Econlit search on "green job" reveals only 2 published articles in English peer-reviewed journals (assessed 3/25/2013).

growth. Further, 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. The preparation and dissemination of such data should be a priority for the relevant statistical agencies of countries investing in green growth programs.

1. Conceptual Framework

Targeted green policies are typically implemented through a combination of tax adjustments and publicly funded investments projects.[4] Examples include tax credits or subsidized interest rates on loans for improving energy efficiency in buildings, various taxes and standards promoting energy efficiency in vehicles, etc. Similarly, public funds are provided as R&D grants and subsidies for the development and generation of solar and other renewable energy, and for training programs targeted at workers in green sectors.

To begin conceptualizing the impact of such policies on labor markets it is useful to consider the simple neoclassical labor demand model with an employment subsidy. For example, the U.S. Tax Relief and Job Creation Act of 2010 offers tax credits to manufacturers of energy efficient dishwashers, clothes washing machines and refrigerators, effectively reducing the costs of hiring for these firms. An employment subsidy will shift the labor demand curve in the sectors where the subsidy is granted, thus increasing both employment and wages in that sector in the short run. This effect is essentially the short-term effect described in the framework below.

Another component of the conceptual framework is the time horizon. Most existing studies consider a dynamic framework for evaluating the impacts of green policies over a varying time horizon. Sustained green policies will have effects on labor markets in the short, medium and long-run. The nature of these effects will differ over time and characterize the transition towards a less carbon-intensive economy. To illustrate this, consider this framework adapted in part from Fankhouser et al. (2008):

■ <u>Short-term effects</u>: Employment grows in subsidized industries (e.g., green construction sector, low-carbon vehicle sector) and/or in sectors that produce goods and services that are complements with the green policy objectives. Employment may decline in sectors producing goods and services that are substitutes to the green policy objectives (e.g., low efficiency vehicles). Labor and especially capital are less mobile in the short-run so the possibilities of adjustment are more limited.

■ <u>Medium-term effects</u>: Employment changes as the impact of the green policy diffuses through all sectors in the economy. Jobs are created and lost along the carbon-intensity

[4] While obviously designed and implemented with green environmental objectives in mind, carbon-pricing policies such Europe's EU-ETS and California's AB32 are not considered as green job policies in this article.

dimension and due to complementarities and substitutability across sectors.[5] Adjustments to the capital stocks begin to reflect the new economic environment.

■ Long-term effects: Capital stocks are freely mobile. Innovation and the development of new technologies create new opportunities for investment. Net effect of targeted policies on employment attenuates over time as labor fully reallocates across sectors.

While useful as a starting point to evaluate green growth policies, this stylized framework ignores important issues that require attention. A central question not addressed is whether green jobs would emerge in the absence of governmental intervention. In other words, would consumer demand for green goods and services alone drive employment growth in these sectors? The literature remains mostly silent on this question. Another issue is whether green growth objectives could be achieved through price incentives as opposed to "industrial policy" push, specifically by increasing the price of fossil-based energy (for example through a carbon tax).

Regarding the transition from the short term to the long term effects of green policies, the main point is that the employment effects are likely to vary across the various time horizons. Employment losses are likely to be significant in carbon-intensive sectors in the short-run, however, in the long-run with full labor mobility across sectors, the overall employment effects may be null or even positive. An important question is what research methods can tell us about the short-term vs. the long-term effects of green policies, and whether these policies lead to growth. While it is possible to identify the short-term effects using empirical methods, long-term effects where inter-sector reallocations are important will primarily be informed from model-based computable general equilibrium (CGE) analysis, although some empirical studies of long-term effects exist.[6]

Another important question ignored to date in the literature is whether green policy investments lead to actual improvements in environmental quality. Every job includes components of "green" and "brown" activity. And so the net effect of a green policy on environmental quality will depend on the types of jobs that are created and destroyed by the implementation of the policy, and on the "green" and "brown" nature of these jobs. A simple approach to answer this question would be to use data on carbon intensity or emissions (e.g., from life-cycle assessment models) associated with various jobs and calculate the net effect on aggregate carbon emissions of the net employment effect of a policy. As the share of green to brown jobs increases we should expect a reduction in carbon emissions in the economy. This reduction can be monetized using estimates of the social cost of carbon (see e.g., Greenstone et al. 2001) and then compared to the size of the public investments in green job policies.

[5] For example a reduction in the coal-powered electricity generation could lead to reduced employment in mining and transportation industries.
[6] See for example Greenstone (2002), Popp (2002), and Walker (2011).

Finally, while most studies of green policies' impacts focus on employment changes as the indicator of cost or benefits associated with a policy, transitional costs associated with reallocating production and workers across sectors are likely to be significant. For example, Walker (2011, 2013) finds significant transitional costs for workers displaced by regulation implemented under the 1990 Clean Air Act Amendments. His analysis shows that ten years after the change in regulation, employment in the impacted sectors remained 15 percent lower than before the change in regulation. Further, Walker also reports persistent earnings losses for workers displaced by the regulation, up to 5 years after the regulatory change, for a total earnings loss equivalent to 20 percent of their pre-regulatory earnings. Given that most studies of green job policies are based on CGE-type models that generally assume immediate reallocation, these potentially important transition costs have not been accounted for properly in the modeling literature.

2. Definitions and Measurement of Green Jobs

While broadly used as a notion of employment in environmentally conscious or clean energy sectors, there is no universally accepted definition of what constitutes a "green job". Most definitions used by statistical agencies and researchers reflect common themes, namely jobs related to the production and distribution of "clean" energy, and to the production of environmental goods and services. Some researchers also define green jobs exclusively as the jobs created by green growth policies. Others, like the United Nations Environmental Program (UNEP), also add qualifications that green jobs must also offer adequate wages, and support workers' rights and safe working conditions.

The Green Goods and Services Survey (GGS) from the U.S. BLS considers two definitions of green jobs:

1. "Jobs in businesses that produce goods and provide services that benefit the environment or conserve natural resources." (output-based definition)

2. "Jobs in which workers' duties involve making their establishment's production processes more environmentally friendly or use fewer natural resources." (process-based definition)

For both definitions, the focus is on goods and services and/or production processes that relate to: (a) Energy from renewable sources, (b) Energy efficiency, (c) Pollution reduction and removal, greenhouse gas reduction, and recycling and reuse, (d) Natural resource conservation, and (e) Environmental compliance, education and training, and public awareness.

Similar definitions are used in other countries. In Germany, the definition refers to "employees who produce environmental goods and services, or employees involved in environment-related activities". At the same time, other countries such as France do not have an official definition of green jobs, even though the country's statistical agency reports green employment counts. See the Supplement to the 2012 OECD Employment Outlook (OECD 2012) for a presentation of country-specific definitions of green jobs. Based on these definitions, examples of green jobs include: manufacturing, installation, and maintenance of solar panels; production and services in sustainable agriculture, enforcement and monitoring of environmental regulations, collection and processing of recyclables, etc.

Combined with the relatively recent interest in green sector jobs, the absence of a clear definition explains why there is little data available on green jobs, except for aggregate counts. This lack of reliable micro data on characteristics of individuals working in green sectors in turn explains why there are no proper microeconometric studies of the employment effects of green policies.

Even after a definition of green jobs is accepted, its credible measurement remains challenging. To illustrate the problem, consider the output-based measure employed by the U.S. BLS: "jobs in businesses that produce goods and provide services that benefit the environment or conserve natural resources." The advantage of this definition is that it allows the agency to select fine industry classifications in which some or all of the employment can be considered green. The U.S. BLS then proceeds in two steps. First, the BLS has identified 333 detailed industries (6-digit NAICS, out of a possible 1192) in which green goods and services are potentially produced, after consulting with industry groups, governmental agencies, etc.[7] Perhaps this restriction is necessary from a practical viewpoint, but it is also a limitation of the BLS data: green goods and services are also likely to be produced in the other 859 industries.

Clearly, both green and non-green employment will occur within and across establishments in these 333 industries. Consider the "Commercial building construction" industry (NAICS 236220). Employment in the construction of LEED-certified buildings clearly represents green employment, while employment in the construction of standard buildings would not. To resolve this, the U.S. BLS conducts an establishment-level survey to learn about green and non-green employment activities within establishments in a second step.[8] Establishments participating in the survey are asked to provide a share of revenue for their green goods or services. In case of establishments with both green and non-green employment, this revenue share was used to obtain the establishment's green employment.[9]

Another limitation of the U.S. BLS approach of measuring the importance of green jobs is that it is based on the 2007 NAICS classifications (at least the existing 2010 U.S. BLS data is – future releases will be based on the 2012 NAICS). Any creation of new green industrial sectors post 2007 will be ignored and thus lead to undercounting. See Pollack (2012) for a more in depth discussion of the limitations of the U.S. BLS green job definition.

With these limitations in mind, it is nevertheless useful to look at the available data. Table 1, adapted from OECD (2012), reports the number (and percentage) of green jobs for 11 countries

[7] http://www.bls.gov/green/final_green_def_8242010_pub.pdf (assessed 3/25/2013)

[8] http://www.bls.gov/respondents/ggs/forms.htm (assessed 3/25/2013)

[9] In case of non-profit or government agencies, the survey directly asks to provide a share of employment involved in the production of green goods or green services.

where such data are available. Despite slight variations in the definitions and measurement, the percentage of green jobs (relative to total employment) is fairly similar across countries, ranging from 2%-3%. Finland has the lowest share (0.24%) and France and Germany have the highest (4.50%). The main point of Table 1 is that green jobs account for a relatively small share of total employment in all countries where the data is available.

Table 2 examines the industrial composition, carbon intensity, and labor market importance of green jobs in the United States. The analysis is based on data from the 2010 U.S. BLS Green Goods and Services Survey (GGS), from a 2010 report by the U.S. Department of Commerce on sectoral carbon intensity, and from the individual-level data on hours worked and earnings from the 2010 American Community Survey (ACS).[10] The variables are linked across 27 broad industry classifications that can be linked across the different data bases.[11] Column (1) reports the 2008 direct carbon intensity, measured in million metric tons (mmt) of CO2 per billion dollars (2000 USD).[12] This measure of carbon intensity provides an alternative metric of how green each sector is. In principle, data on carbon intensity could be used to as a metric to compute changes in environmental quality associated with changes in employment across industrial sectors. Not surprisingly, sectors like transportation, primary metals, and nonmetallic mineral products have high carbon intensity, exceeding 1 mmt per $billion of output. Across all industries, the hours-weighted average carbon intensity is 0.23. This reflects the fact that more than 50% of total hours worked in the U.S. in 2010 were in the relatively low-carbon intensity service sector.

Column (2) displays the BLS measure of percent green jobs (relative to total employment) in each industry. For example, these data indicate that 20% of employment in Forestry & Logging is 'green', while essentially no jobs in Financial Activities, Education & Health Services, and Leisure & Hospitality are green. Across all industries, the hours-weighted percent of green jobs is about 3%. Further, the correlation between carbon intensity and percentage of green jobs across industries is relatively weak. It is evident that the sectors with the highest concentration of green jobs are the primary and manufacturing sectors, the sectors with the largest carbon intensity. At the same time, the concentration of green jobs in the service sector – one that accounts for roughly half of all hours worked in the U.S. economy– is relatively smaller. Nevertheless, a key point of column (2) is that it clearly establishes, at least in the U.S., that green jobs are not only jobs associated with the specific sectors such as renewable energy industry (e.g., solar panel production and installation), but rather are represented in most of the major industrial sectors.

[10] Ruggles et al. (2010)

[11] Unfortunately, some sectors like government & public administration cannot be consistently linked across the data bases and therefore excluded from the analysis. The 27 industries considered account for 90% of the U.S. workforce.

[12] The industry-specific carbon intensity measures are derived by applying CO2 conversion factors to industry-specific energy use data. See Department of Commerce (2010) for more details.

Columns (3) and (4) report the share of total hours worked and share of total wage bill (total hours worked times average hourly earnings) by industry, relative to the aggregate U.S. workforce. For both hour shares and wage bill shares, the data shows a negative correlation, that is, the industries with higher concentrations of green jobs typically have lower shares of hours worked and wage bill earned. For example, Primary Metals has 18.5% of its employment falling under the GGS definition of the U.S. BLS, yet the sector accounts for only 0.5% of total hours worked and total wage bill in the U.S. in 2010. Similarly 19.8% of employment in Forestry & Logging is green, but the sector accounts for only 0.1% of total hours worked and total wage bill in the U.S. in 2010. On the other hand, only 0.2% of employment in Education and Health Services contributes to the production of green goods and services, but it alone accounts for more than 25% of all hours and earnings in the U.S. economy.

Figure 1 displays the trends in the share of hours worked and total wage bill in the United States from 2001-2010 for the top 50% 'greenest' industries in Table 2.[13] The trends clearly show little progress in employment and wages in these sectors during the 2000s, with both series indicating relatively constant green shares, at about 30% of aggregate hours and 32% of the aggregate wage bill. These shares also appear to dip slightly during the 2008-2009 Great Recession period. This very simple descriptive evidence appears to invalidate the premise that green sectors grow faster than brown sectors. This premise underlies most of the argument for why green job policies can deliver job growth and can be long-term drivers of sustainable economic growth (UNEP 2008). Clearly more detailed empirical microeconomic research is needed to offer better empirical evidence and testing of the central hypotheses in green growth theory.

3. Review of the Existing Employment Studies

A significant number of studies, primarily based on computer simulations (CGE-type modeling) and input/output table analysis, have been conducted to evaluate the job growth potential of variously defined green job policies in Europe and in the United States (see e.g., GHK 2009, GCN 2010, and Bowen 2012 for extensive reviews of this literature). Notably, few of these studies have been published in peer-reviewed academic journals. Rather they appear as reports or working papers. For example, none of 29 studies reviewed in GHK 2009 are published in peer-reviewed journals.

Given the considerable heterogeneity in the scope and assumptions of these studies and the absence of a formal peer-review process for most existing studies it is very difficult to draw definitive and broad conclusions.[14] In addition, studies vary greatly in the scope of policies

[13] The industries with above median percent green jobs are: crop production, forestry and logging, utilities, construction, textile products, furniture and wood products, paper, nonmetallic mineral products, primary metals, machinery, appliances and electronics, transportation and warehousing, and professional, scientific, and technical services.

[14] GHK (2009) note that the employment change estimates of green policy studies are not comparable due to many factors, including difference in the consideration of gross or net employment effects,

evaluated. Some consider single renewable energy policies while others evaluate multiple policies in combination, including renewable energy targets, carbon-pricing policies, etc. Others ignore the indirect effect of green policies on job destruction in brown sectors, or other general equilibrium effects. It should be noted that these limitations are in addition those embodied in CGE analysis by construction. In the context of green job policies, an especially important limitation of CGE models is that they typically assume inelastic labor supply and free labor mobility across sectors. This implies that all adjustments occur quickly, and only through wage changes, ruling out frictional unemployment.[15] It is unclear how much the combination of such assumptions leads to systematic biases in the CGE analysis.

As stated earlier, the limited availability of labor micro data with information on green jobs explains why there is no direct "program evaluation" evidence on green job policies. In fact there are very few empirical studies altogether. This is in contrast with the literature focusing on employment effects of carbon-pricing policies in the United States, where empirical studies and modeling studies have been successfully conducted (see e.g., Deschenes 2012, Kahn and Mansur 2010, Morgenstern, Ho, and Shih 2008).

These important limitations notwithstanding, the consensus appears to be one where green policies can deliver employment growth. In his review, Brown (2012) also notes this and writes that taken together the evidence suggests "that climate-change policies in general and renewable energy policies in particular can generate considerable extra employment," also adding that "environmental policies will lead to substantial job creation only if other inefficiencies—including those of labor markets—are tackled."

In my view, there are too many limitations associated with the existing studies to reach a firm consensus. Conclusions such as the one presented in Brown (2012) may turn out to be correct, but there is not enough empirical evidence to support them. Two key limitations need to be addressed before a more definitive conclusion can be reached. First, statistical agencies need to accelerate the data collection process on green jobs and provide the appropriate micro data sets to the researchers. Researchers need access to large data bases with detailed worker-level information on demographic attributes, job attributes (including measures of jobs' green content), hours worked, wages, etc. This process is slowly beginning in the U.S., but more countries need to follow suit.

Second, more careful and detailed empirical work is required to evaluate the job creation potential of green policies, and to inform the simulation models employed in making such assessments. In particular, more labor economists need to begin producing research in this area. The rigorous evaluation of publicly-funded job training programs in the U.S. and Europe done by labor economists has been important in improving the design of such programs, and in developing methodological tools for evaluation (see e.g., Ashenfelter 1978, Heckman, Lalonde,

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differing assumptions concerning economic growth and the effect of existing business as usual policies, etc.

[15] See Wing (2004) for a clear a discussion of the main limitations of CGE models.

and Smith 1999). If green policies are to be successful in solving unemployment and environmental problems, the same standards of evaluation should apply to them. These empirical studies should aim to credibly document the short run effects of green growth policies on employment, wages, unemployment duration, as well as the transitional costs associated with labor and production reallocation.

Final Remarks and Conclusions

Massive public investments have been made and proposed to promote green growth and green jobs, yet little is known about their impacts on labor market outcomes. This reflects the lack of readily available micro data, the focus on long-term simulation analysis as opposed to program evaluation-type empirical studies, and the lack of homogeneity in the study settings and policy scenarios considered. Moving beyond labor market impacts, the improvements in environmental quality associated with green policies also need to be carefully evaluated. There remains a large agenda for future research in all of these areas.

References:

Ashenfelter, O. "Estimating the effect of training programs on earnings." *The Review of Economics and Statistics* 60, no. 1 (1978): 47-57.

Berman E., and L. Bui (2001): "Environmental Regulation and Labor Demand: Evidence from the South Coast Air Basin," Journal of Public Economics, 79, pp: 265-295

Bowen, A. (2012), "Green" Growth, "Green" Jobs and Labor Markets, World Bank, Policy Research Working Paper, 5990

Deschenes, O. (2012): "Climate Policy and Labor Markets", in *The Design and Implementation of U.S. Climate Policy*, Edited by Don Fullerton and Catherine Wolfram, University of Chicago Press, 2012.

GCN (2010): Low-carbon Jobs in an Interconnected World, Global Carbon Network Discussion Paper No. 3 and Literature Review, March.

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, May

Greenstone, M. (2002): "The Impacts of Environmental Regulations on Industrial Activity: Evidence from the 1970 and 1977 Clean Air Act Amendments and the Census of Manufactures," Journal of Political Economy, 110(6): pp. 1175-1219

Greenstone, M, Kopits, E. and Wolverton, M. Estimating the Social Cost of Carbon for Use in U.S. Federal Rulemakings: A Summary and Interpretation (March 23, 2011). MIT Department of Economics Working Paper No. 11-04. Available at SSRN: http://ssrn.com/abstract=1793366 or http://dx.doi.org/10.2139/ssrn.1793366

Heckman, J., R. LaLonde, and J. Smith. "The economics and econometrics of active labor market programs." Handbook of Labor Economics 3 (1999): 1865-2097.

HSBC (2009): "A Climate for Recovery: The Colour of Stimulus Goes Green," Website: www.research.hsbc.com [assessed: 3/21/13].

Jaffe, A., S. Peterson, P. Portney, and R. Stavins (1995): "Environmental Regulation and the Competitiveness of U.S. Manufacturing: What Does the Evidence Tell Us?" Journal of Economic Literature, 33(1): pp. 132-163

Kahn, M. E., and Mansur, E. T. (2010): "How do energy prices, and labor and environmental regulations affect local manufacturing employment dynamics? A regression discontinuity approach," NBER Working Paper No. 16538.

Ho, M., R. Morgenstern, and J. Shih (2008): “Impact of Carbon Price Policies on U.S. Industry,” Resources for the Future Discussion Paper 08-37.

OECD (2012), “What Green Growth Means for Workers and Labour Market Policies: An Initial Assessment,” in OECD, OECD Employment Outlook 2012, OECD Publishing. doi: 10.1787/empl_outlook-2012-5-en

Popp, D., 2002, ‘Induced innovation and energy prices’, American Economic Review 92, 160–180.

Ruggles, S., T. Alexander, K. Genadek, R. Goeken, M. Schroeder, and M. Sobek. (2010): Integrated Public Use Microdata Series: Version 5.0 [Machine-readable database]. Minneapolis: University of Minnesota

UNEP (2008): Green Jobs: Towards Decent Work in a Sustainable Low Carbon World: United Nations Environment Program

U.S. Department of Commerce (2010): “U.S. Carbon Dioxide Emissions and Intensities Over Time: A Detailed Accounting of Industries, Government and Households,” http://www.esa.doc.gov/Reports/u.s.-carbon-dioxide [assessed 3/26/2013]

Walker, R. (2011): “Environmental Regulation and Labor Reallocation," American Economic Review: Papers and Proceedings, 101(2)

Walker, R. (2013): “The Transitional Costs of Sectoral Reallocation: Evidence From the Clean Air Act and the Workforce,” Mimeographed, UC Berkeley.

Wing, Ian Sue. "Computable general equilibrium models and their use in economy-wide policy analysis." MIT. Joint program on the science and policy of global Change 6 (2004).

Table 1: Number and Percentage of Green Jobs, Various Countries

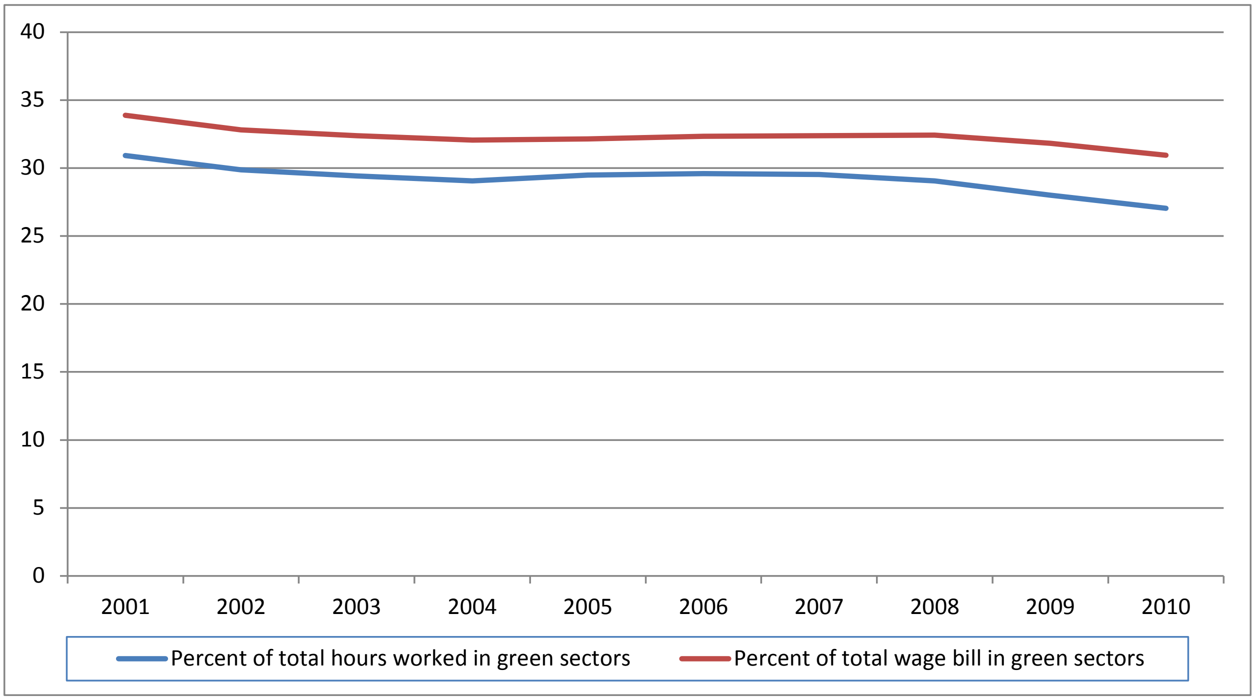
	Number of Green Jobs	Percent of Total Jobs 'Green'	Data Year
Austria	162,986	3.99%	2008
Finland	5,888	0.24%	2009
France	---	1.60%	2010
Germany	---	4.50%	2006
Hungary	200,000	4.18%	2020
Japan	1,400,000	2.19%	2008
South Korea	604,400	2.56%	2008
Portugal	---	0.40%	2008
Spain	531,000	2.62%	2008
Swizerland	---	4.50%	2009
United States	3,100,000	2.43%	2010

Notes: Adapted from OECD (2012).

Table 2: Industrial Distribution and Characteristics of Private Sector Green Jobs in United States

Industry	Carbon Intensity	% of Industry Employment 'Green' (2010)	% of Total Hours Worked (2010)	% of Total Wage Bill (2010)
Crop Production	0.09	6.9	0.7	0.4
Animal Production	0.25	3.7	0.4	0.2
Forestry & Logging	0.05	19.8	0.1	0.1
Mining	0.09	---	0.8	0.9
Utilities	---	11.9	1.1	1.6
Construction	0.16	6.8	6.2	5.9
Manufacturing	---	---	**12.4**	**14.2**
Textile Product Mills	0.14	10.7	0.5	0.3
Furniture & Wood Products	0.20	7.4	0.8	0.6
Paper	0.61	7.8	0.9	0.9
Petroleum & Coal Product	1.21	2.8	2.6	3.4
Chemicals	0.62	3.7	1.2	1.7
Plastics and Rubber Products	0.28	0.9	0.6	0.7
Nonmetallic Mineral Products	1.61	9.6	0.4	0.4
Primary Metal	1.05	18.5	0.5	0.5
Fabricated Metal Products	0.19	2.6	0.7	0.7
Machinery	0.12	7.1	1.6	1.9
Appliance & Electronic Products	0.08	11.1	2.8	3.5
Transportation Equipment	0.10	2.9	1.9	2.4
Trade (Wholesale & Retail)	0.16	1.0	15.6	12.8
Transportation and Warehousing	1.22	6.2	4.8	4.5
Services	---	---	**48.9**	**53.1**
Information	0.03	1.4	0.2	0.3
Financial Activities	0.07	0.0	8.6	11.8
Prof., Scientific and Tech. Services	0.01	4.7	6.7	10.4
Administrative and Waste Services	0.01	4.3	4.1	3.1
Education and Health Services	0.16	0.2	25.8	26.2
Leisure and Hospitality	0.27	0.2	9.0	5.2
Other Services	0.02	1.3	4.2	3.2

Figure 1: Percentage of Aggregate Hours Worked and Total Wage Bill in U.S. BLS 'Greenest' Industries in United States, 2001-2010



Notes: Author's calculations based on 2001-2010 American Community Surveys.