Using Empirical Occupational Transitions to Inform the Labor Market Implications of Clean Energy Transition

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Motivation and Project Summary

What are the consequences of transitioning away from fossil fuels for workers? This research explores the potential labor market implications of the clean-energy transition, focusing on the skills that workers in "brown" and "green" jobs tend to possess and the realistic outside options that they therefore command. In particular, we use occupational transition shares computed from over 16 million resumes and realized job-to-job transitions from Schubert, Stansbury, and Taska (2021) to explore the distributional implications of a transition away from carbon-intensive production technologies, as well as potential efficiency costs in the form of retraining and relocation costs.

Background and Existing Evidence

A growing literature examines the labor market consequences of technical change, including the rise of industrial robots (Acemoglu and Restrepo, 2020) and skill-biased technical change more broadly (Autor, Levy, and Murnane, 2003). One way to view climate mitigation policy is as a form of directed technical change away from carbon-intensive production processes. If labor markets are perfectly competitive, there are no efficiency costs arising from the associated labor reallocation, as workers and firms costlessly adjust to new optimal input mixes by switching jobs and moving to areas with greater labor demand. In practice, search frictions, human capital acquisition costs, or other labor market imperfections may give rise to significant transition costs – e.g. in the form of scarring effects or higher rates of unemployment and reduced labor force participation – especially in a world where labor markets are locally segmented (Autor, Dorn, and Hanson, 2013; Manning, 2021). In either case, the effects of environmental policy on labor demand may have important distributional implications.

Recent evidence suggests that environmental regulations can have significant consequences for local labor markets. A growing literature finds that the wage and employment implications of environmental regulation can vary by industry and region. For instance, Greenstone (2002) estimates that the U.S. Clean Air Act resulted in over 590,000 lost jobs in counties and industries that were historically heavily polluting. Curtis (2018) finds that overall employment in energy-intensive industries fell by up to 4.8% in the wake of the NOx trading program. Conversely, some analyses suggest that future "green jobs" could be plentiful and well-paying, resulting in net employment impacts that are positive (Lehr, Lutz, and Edler, 2012), and that well-designed labor market policies may help transition workers from out of historically "brown" sectors.

One important knowledge gap pertains to the extent to which the skills demanded by "greener" sectors overlap (or not) with those in traditionally "brown" sectors. Consider the following statement by former national climate adviser Gina McCarthy: "Take the U.S. manufacturing sector... It has relied on a fossil-fuel based system for nearly 200 years, so *reshaping the system means ensuring that these industrial workers get the training and resources to build the clean energy economy* (emphasis added)."

Whether the workers who are currently employed in carbon-intensive jobs can be effectively matched to the jobs that will be demanded in a clean-energy economy is not immediately obvious. The answer depends in part on the degree of similarity in the kinds of jobs, the skills and potential

training needed for such occupational transitions, and the availability of such jobs in relatively close geographic proximity. Our motivation is to use observed occupational transitions to inform this question empirically.

Empirical Challenges and Research Strategy

Answering such questions requires having a detailed understanding of outside options: the jobs that workers in a given occupation tend to have access to given their existing human capital and preferences. An electrical engineer employed in the fossil fuel industry may be able to find work in similar occupations in a renewable energy firm. Could the same be said for oil derrick operators? To what extent might such transitions also be constrained by geography?

In this project, ask the following research questions:

1. What are the outside occupation options typically available to workers in "brown" jobs? Similarly, which occupations are most likely to transition into "green" jobs?

2. What are the distributional implications of such employment transitions - both across the skills distribution and across geographies?

3. What are the potential transitional costs of reallocating workers currently employed in "brown" jobs to "green" jobs?

In addition to novel descriptive analyses of observed occupational transitions, we hope to provide an empirical assessment of the wage and non-wage characteristics of the outside options of workers most likely to experience reduced labor demand due to climate mitigation policy, as well as an estimate of the potential costs associated with transitioning some subset of workers out of "brown" and into "green" jobs, given observed skill-, industry- and geographic-distributions.

Methodology

We do so by using data on (1) occupational task and work setting characteristics from job postings from Burning Glass Technologies; (2) occupation-industry employment information from the Bureau of Labor Statistics (BLS); (3) occupational transition shares computed using job-transitions from 16 million+ resumes compiled by Burning Glass, as constructed by Schubert, Stansbury, and Taska (2021); as well as other publicly available data sets describing, among other things, non-wage amenities associated with a given occupation (e.g. workplace safety) from the BLS and O*NET.

By using data from (1) and (2), we can categorize jobs as "brown" or "green", following methods described in Curtis and Marinescu (2022), and estimate the geographic distribution of employment in each category. For instance, we would expect a relatively low share of accountants or sales representatives to be employed in brown industries. Conversely, the corresponding share of wellhead pumpers or petroleum engineers to be relatively high.

Combining this information with occupation-specific transition matrices from (3) allows us to generate measures of the realistic transition probabilities into and out of both brown and green jobs. By using occupational transition shares resulting from job-to-job transitions for over 16 million workers (with longitudinal data representing over 80 million jobs), Schubert, Stansbury, and Taska (2021) measure the share of workers that are able to move out of a given occupation and into another one.

We follow Schubert, Stansbury, and Taska (2021) and define occupational transition shares as:

$$\begin{aligned} transitionshare_{o \to p} &= Pr(\text{move from occ } o \text{ to occ } p \mid \text{leave occ } o) \\ &= \frac{\text{Share from occ } o \text{ moving into occ } p}{\text{Share from occ } o \text{ moving into any new occ}} \\ &= \frac{\#\text{ in occ } o \text{ in year } t \text{ observed in occ } p \text{ in year } t{+}1}{\#\text{ in occ } o \text{ in year } t \text{ observed in any new occ in year } t{+}1} \end{aligned} \quad (1)$$

This allows the identification of, for instance, the "thickest" transition pathways observed in the data for Extraction Occupations. Using information on local (SOC-MSA) wages, we can characterize the average outside option value for a given "brown" occupation, computed separately by industry and MSA. We can also characterize non-wage job characteristics in a similar way, using data on occupational safety (e.g. rate of workplace injuries), educational requirements, and other occupational task requirements.[1]

Preliminary Analyses

Table 1 lists the top 20 outside occupation options of "Extraction Occupations (SOC 47-5000)", ranked by the empirical occupational transition share over the period 2002-2018. As shown, while many former extraction workers become computer user and support specialists, many also become heavy tractor-trailer truck drivers and customer service representatives.

Table 2 lists the top 20 source occupations into "Solar Installer Jobs (47-2231)," ranked according to the percent of transitions to Solar jobs that came from various occupations. The top line of the table shows that 6.35% of all transitions to Solar came from Electricians while 6.19% came from Telecommunications equipment installers. Not surprisingly, transitions to these Solar and Wind jobs tend to come from other blue-collar occupations. Table 3 reports the same statistics for those entering the Wind Turbine Maintenance jobs and demonstrates similar patterns.

In Figure 1 we use the SOC6-to-SOC6 transition matrices provided by Schubert, Stansbury, and Taska (2021) to calculate the outside option value for 690 six-digit occupations. For each occupation, the outside option value is the weighted average of wages in all other occupations, with weights equaling the occupational mobility transition rates to each other six digit occupation (to proxy for the likelihood that an occupation could be a relevant outside option). In Panel A, we report the distribution of these outside option values allowing for workers to transition to Brown Occupations. Panel B considers a world in which workers are not able to transition to brown occupations, in which we report the distribution of these outside option values assuming workers have zero probability of transitioning to Brown Occupations.[2]

The distributions in Panels A and B look quite similar. The average outside option value (as seen in the green vertical lines) across all occupations is almost unchanged when not allowing for transitions to Brown occupations. However, the outside option value for Mining occupations (as seen by the red lines) falls by approximately $4,000 (6 percent), when not allowing transitions to Brown Occupations. This suggests that workers in Mining would have significant loss in their outside option value if they were not able to transition to other Brown occupations. This estimate may be overstated to the extent that not all brown jobs may experience reduced labor demand as a result of a clean energy transition. It may be understated given the narrow definition of Brown Occupations used.

[1] Utilizing information on educational attainment and occupational skill composition, we can also characterize the extent to which moving from brown to green jobs entails "upskilling" (or "downskilling"), and whether workers can expect increases or reductions in pay in the event of a successful transition.

[2] As a starting point, we define a Brown Occupation as any occupation in SOC 47-5 (mining and extraction jobs). We hope to refine this definition in future work.

Future work will relate these transition probabilities and outside option values to the existing geographic distribution of jobs in each category. We can also provide suggestive information regarding the potential implications of the clean-energy transitions for regional disparities in labor market outcomes.

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Table 1: Top 20 Outside Occupation Options for Extraction Occupations (47-5000)

Destination occupation	SOC	Transitions
Managers, all other	11–9199	2557.4
Maintenance and repair workers, general	49–9071	2195.3
Computer user support specialists	15–1151	1654
Heavy and tractor-trailer truck drivers	53–3032	1362.5
Telecommunications equipment installers and repairers, except line installers	49–2022	938.5
Computer occupations, all other	15–1199	789.5
General and operations managers	11–1021	712.8
Production workers, all other	51–9199	623.5
First-line supervisors of retail sales workers	41–1011	556.1
Sales representatives, wholesale and manufacturing, except technical and scientific products	41–4012	488.6
Management analysts	13–1111	469.3
Laborers and freight, stock, and material movers, hand	53–7062	468.7
Network and computer systems administrators	15–1142	450.9
First-line supervisors of mechanics, installers, and repairers	49–1011	446.1
Engineers, all other	17–2199	415.7
Customer service representatives	43–4051	407.5
Engineering technicians, except drafters, all other	17–3029	404.8
Rotary drill operators, oil and gas	47–5012	389.3
Security guards	33–9032	386
Computer systems analysts	15–1121	341.2

Notes: Transitions are ranked according to the total number of transitions to that occupation from Extraction Occupations. Transition shares come from Schubert et al (2020), who use data from Burning Glass Technologies (BGT) on job postings from 2007-2019, a subset of which included resumes from workers for whom job-to-job transitions can be observed.

Table 2: Top 20 Sending Occupations into Solar Installer Jobs (47-2231)

Occupation	SOC	Percent Transitions
Electricians	47-2111	.0635375
Telecommunications equipment installers and repairers, except line installers	49-2022	.061917
Laborers and freight, stock, and material movers, hand	53-7062	.0459032
Heavy and tractor-trailer truck drivers	53-3032	.0458955
First-line supervisors of food preparation and serving workers	35-1012	.0314031
Retail salespersons	41-2031	.030255
Construction laborers	47-2061	.0254486
Marketing managers	11-2021	.023654
Managers, all other	11-9199	.0209465
Teachers and instructors, all other	25-3099	.0193643
Customer service representatives	43-4051	.0190973
Stock clerks and order fillers	43-5081	.018846
Transportation, storage, and distribution managers	11-3071	.0186298
Management analysts	13-1111	.0167966
Industrial truck and tractor operators	53-7051	.0162766
Construction managers	11-9021	.0155256
First-line supervisors of mechanics, installers, and repairers	49-1011	.0147599
Welders, cutters, solderers, and brazers	51-4121	.0144462
Maintenance and repair workers, general	49-9071	.0128997
Carpenters	47-2031	.0120586

Notes: Table 2 provides the top 20 occupations that transition to Solar installer. The first row shows that 6.35% of all transitions to Solar were from electricians.

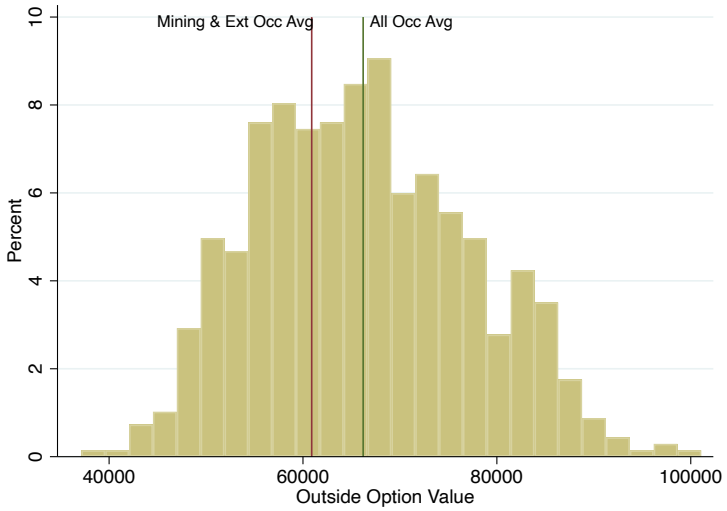
Table 3: Top 20 Sending Occupations into Wind Installer Jobs (49-9081)

Occupation	SOC	Percent Transitions
Managers, all other	11-9199	.0557943
Maintenance and repair workers, general	49-9071	.0367758
Education administrators, postsecondary	11-9033	.0342737
Vocational education teachers, postsecondary	25-1194	.0263598
Electricians	47-2111	.0232744
Training and development specialists	13-1151	.0230915
Computer user support specialists	15-1151	.0215631
Operations research analysts	15-2031	.0197196
Carpenters	47-2031	.019692
Mechanical engineers	17-2141	.0192006
Graphic designers	27-1024	.0191533
Heavy and tractor-trailer truck drivers	53-3032	.0190453
Electrical and electronics engineering technicians	17-3023	.0182547
Automotive service technicians and mechanics	49-3023	.0175656
Industrial engineering technicians	17-3026	.0173019
Retail salespersons	41-2031	.0167895
Packers and packagers, hand	53-7064	.0162083
Aircraft mechanics and service technicians	49-3011	.0153234
Production workers, all other	51-9199	.0141915
Laborers and freight, stock, and material movers, hand	53-7062	.0134358

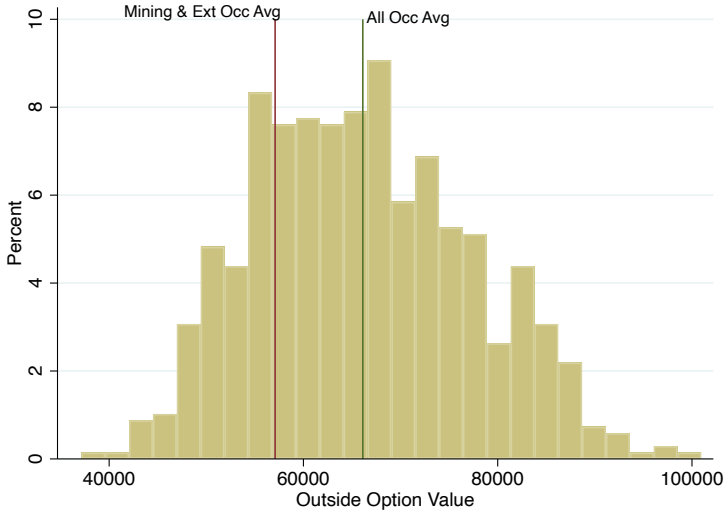
Notes: Table 3 provides the top 20 occupations that transition to Wind installer. The first row shows that 5.58% of all transitions to Wind were from managers.

Figure 1: Distribution of 6-Digit SOC Outside Option Values

(a) Allowing for Transitions to Brown Occs



(b) Not Allowing for Transitions to Brown Occs



Notes: Using the SOC6-to-SOC6 transition matrices provided by Schubert, Stansbury, and Taska (2021), we calculate the outside option value for 690 six-digit occupations. For each occupation, the outside option value is the weighted average of wages in all other occupations, with weights equaling the occupational mobility transition rates to each other six digit occupation (to proxy for the likelihood that an occupation could be a relevant outside option). In Panel a, we report the distribution of these outside option values allowing for workers to transition to Brown Occupations. In Panel B, we report the distribution of these outside option values when ***not*** allowing workers to transition to Brown Occupations. As a starting point, we define a Brown Occupation as any occupation in SOC 47-5 (mining and extraction jobs). The distributions in Panels a and b are quite similar. The average outside option value (as seen in the green vertical lines) is almost unchanged when not allowing for transitions to Brown occupations. However, the outside option value for the Mining occupations (as seen by the red lines) falls by approximately $4,000, when not allowing transitions to Brown Occs.