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## Working Paper

# Who's fit for the low-carbon transition? Emerging skills and wage gaps in job and data

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# Working Paper

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## **Who's fit for the low-carbon transition? Emerging skills and wage gaps in job and data**

**Aurélien Saussay, Misato Sato, Francesco Vona  
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By **Aurélien Saussay** (Grantham Research Institute, London School of Economics and Political Science and OFCE, Sciences Po)

**Misato Sato** (Grantham Research Institute, London School of Economics and Political Science)

**Francesco Vona** (University of Milan, Fondazione Eni Enrico Mattei and OFCE, Sciences Po)

**Layla O'Kane** (Lightcast)

## Summary

As governments worldwide increase their commitments to tackling climate change, the number of low-carbon jobs are expected to grow rapidly. Here we provide evidence on the characteristics of low-carbon jobs in the US using comprehensive online job postings data between 2010-2019. By accurately identifying low-carbon jobs and comparing them to similar jobs in the same occupational group, we show that low-carbon jobs differ from high-carbon or generic jobs in a number of important ways. Low-carbon jobs have higher skill requirements across a broad range of skills, especially technical ones. However, the wage premium for low-carbon jobs has declined over time and the geographic overlap between low- and high-carbon jobs is limited. Overall, our findings suggest the low-carbon transition entails potentially high labour reallocation costs associated with re-skilling and earning losses, indicating public investments in skills is needed to deliver a smooth and rapid transition.

## Keywords:

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### *Address for correspondence:*

Aurélien Saussay

Assistant Professorial Research Fellow, Grantham Research Institute  
London School of Economics and Political Science, Houghton Street  
London, WC2A 2AE, United Kingdom

e-mail: [a.saussay@lse.ac.uk](mailto:a.saussay@lse.ac.uk)

*The opinions expressed in this paper do not necessarily reflect the position of Fondazione Eni Enrico Mattei*

# Who's fit for the low-carbon transition? Emerging skills and wage gaps in job and data

Aurélien Saussay,<sup>1,2\*</sup> Misato Sato,<sup>1</sup> Francesco Vona,<sup>3,4,2</sup> Layla O'Kane<sup>5</sup>

<sup>1</sup>Grantham Research Institute, London School of Economics and Political Science,  
Houghton Street, London, WC2A 2AE, U.K.

<sup>2</sup>OFCE, Sciences Po, 10 place de Catalogne, Paris, 75014, France

<sup>3</sup>University of Milan, Via Festa del Perdono 7 - 20122 Milano, Italy

<sup>4</sup>FEEM, Corso Magenta 63 - 20123 Milano, Italy

<sup>5</sup>Lightcast

\*To whom correspondence should be addressed; E-mail: a.saussay@lse.ac.uk.

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**As governments worldwide increase their commitments to tackling climate change, the number of low-carbon jobs are expected to grow rapidly. Here we provide evidence on the characteristics of low-carbon jobs in the US using comprehensive online job postings data between 2010-2019. By accurately identifying low-carbon jobs and comparing them to similar jobs in the same occupational group, we show that low-carbon jobs differ from high-carbon or generic jobs in a number of important ways. Low-carbon jobs have higher skill requirements across a broad range of skills, especially technical ones. However, the wage premium for low-carbon jobs has declined over time and the geographic overlap between low- and high-carbon jobs is limited. Overall, our findings suggest the low-carbon transition entails potentially high labour reallocation costs associated with re-skilling and earning losses, indicating public investments in skills is needed to deliver a smooth and rapid transition.**

Reaching climate neutrality by mid-century requires a deep transformation of all economic sectors [40]. In parallel with ongoing technological trends in digitization and Artificial Intelligence [8, 1], the low-carbon transition reshapes labour markets, by reallocating workers towards low-carbon activities whilst skills demanded by high-carbon activities may be lost with job displacement. The political imperative of delivering jobs [28] and supporting a “just transition” that addresses the needs of workers and communities of high-carbon industries is a key priority to enhance the political acceptability of climate action [45].

Yet understanding the skill content and other characteristics of low-carbon jobs vis-à-vis high-carbon or generic jobs remains a challenge, owing to the fundamental problem of identifying low-carbon jobs with precision. High-carbon jobs linked to fossil fuels extraction and production are easily identified, but conceptual issues and data limitations make it significantly more difficult to define the jobs that will benefit from ambitious climate policies. While the transition will create some new occupations, in the majority of cases, the greening of jobs is happening within established occupations as the job content is altered with the adoption of new green technologies or new green production methods [47] e.g. automobile engineers adapting to hybrid, electric or hydrogen technologies. Because of the lack of agreed definition of what a green job is, the discourse has tended to narrowly focus on segments of the green economy such as renewable energy [18] or traditional environmental sectors like waste and water. Consequently, public debate exaggerates the job killing argument while downplaying the job creation effect of the low-carbon transition [45]. Moreover, the evidence is largely silent on reallocation costs associated with workers’ reskilling [47] and earning losses [49], which are often ignored when evaluating labour market impacts of environmental policies [26, 36, 30, 27, 33, 16, 32].

Recent studies made substantial progress by combining insights from the task-based approach to labour markets [8, 1] with occupation-level data on task and skill requirements from the Green Economy Program of the Occupational information network (O\*NET) [46, 17, 47,

14, 48, 44] to measure occupation level exposure to green technologies and productions. Using this approach [47] shows that greener occupations require more technical & engineering and managerial skills. Yet isolating and comparing greening jobs from similar non-green jobs in the same occupation has not been possible with occupational level data.

Here we gain job-level perspectives by developing a new three step procedure to accurately isolate low-carbon activities in online job vacancy data (see Figure 1 and Methods), combining natural language processing and expert survey. Following the recent literature on labour market adjustments to technological change [20, 29, 21, 10, 2], we use the comprehensive online job ads data from Lightcast (formerly Emsi Burning Glass), covering the near-universe of online job vacancies posted in the US between 2010 and 2019.

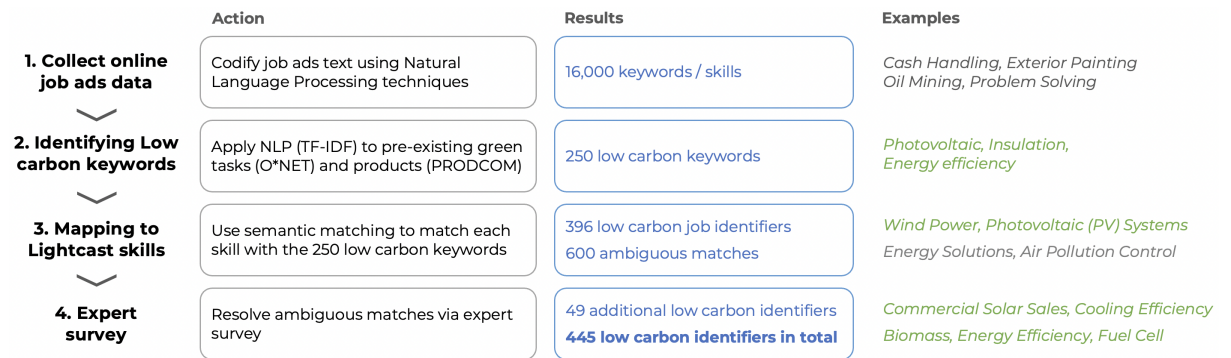


Figure 1: Identifying low carbon jobs using job ads data

Taking advantage of the high density of low-carbon job ads in particular occupations, our approach allows us to reveal precisely how low-carbon jobs compare in terms of geographical distribution, skill requirements and wages vis-à-vis fossil fuel or similar jobs within occupational groups, such as engineers or construction workers. In doing so, we provide a very accurate characterisation of the potential skill gaps and hiring difficulties emerging in specific labour markets concerned by the low-carbon transition. The methodology is transparent and flexible, and can be easily replicated in different country contexts, offering a toolkit for policymakers to

design targeted retraining and reskilling policies within green deal packages. The adaptability is key given the nature of green jobs is likely to continue to change through the diffusion of green technology in the economy as the low carbon transition advances.

## **Results**

### **Evolution of demand for low-carbon jobs**

In contrast to the general rise in renewable power production jobs [39], the share of overall low-carbon vacancies in total online job vacancies first increased (from 1.32% in 2010 to 1.44% in 2012 coinciding with the job creation effect of the American Recovery and Reinvestment Act, ARRA) [3, 39], then declined below 1.3% in the central period, and increased again from 2017 onwards (Figure 2). Importantly, job ad shares captures the flow of labour demand rather than the stock of workers in low-carbon positions. Here, low carbon job ads are re-weighted using BLS employment shares to improve representativeness (See Methods and Table SI.6), yielding estimates that are consistent with previous measures of green employment shares [48].

Our disaggregated data and broad definition of low-carbon jobs reveals divergent decennial trends between high- skilled occupations (such as managers or engineers) that decline from 0.36% to 0.30%, and low-skill occupations (such as manual workers) that grow from 0.97% to 1.12% (see Figures 2A and Table SI.10 in the SI). Such trends resonate with the job creation effect of green ARRA spending that was concentrated in manual occupations [39], and suggests that green recovery plans could help to offset secular deterioration of the labour market conditions for unskilled workers. The emerging patterns are rather small in absolute terms but statistically significant (see Table SI.12 in the SI).

Our broad definition identifies low-carbon jobs across most sectors, especially service sectors such as public transport and professional services (Table SI.11). In terms of occupations, six 2-digit SOC groups stand out: Business and Finance 3.6%; Architecture and Engineering

4.1%; Life, Physical and Social Science; Construction and Extraction 4.1%; Installation, Maintenance and Repair 2.6% and Transportation 7.3% (Table SI.7 and Figure SI.3). The latter is due to public transportation and bus driving being included in our list of low-carbon identifiers. Except for transport, these occupations are also the most green-task intensive using O\*NET data [48]. Looking more closely, five high-skilled occupations defined at the more narrow 3-digit SOC level have particularly high shares of low-carbon ads (Business Specialists, Architects, Engineers, Technicians, Physical Scientists) (Table SI.8). We examine difference between low-carbon and generic jobs in these 3-digit occupation. For low-skilled occupations instead, we consider three 2-digit SOC groups with high intensity of low-carbon ads (Construction and Extraction; Installation and Maintenance; Transportation). This is because worker mobility is higher for low-skilled workers across 3-digit occupations that require few months of retraining, while high-skilled workers require substantial formal education (i.e. from biology to physics) to switch between 3-digit occupations.

The data shows varying trends across the eight key low-carbon intensive occupations (Figure 2B). Small declines in low-carbon intensity are statistically significant for Business Specialists (from 2.9% to 1.9%), Architects (from 5.4% to 4.6%) and Engineers (from 5.2% to 3.9%) but not for Technicians and Physical Scientists (See Table SI.13 in the SI). The increase in the low-carbon job share in Construction (from 3.5% to 4.6%) and Installation (from 2% to 3.1%) is statistically significant while in Transportation the share is flat. The unweighted (dotted) share of low-carbon ads is smaller than the weighted for most occupations, but trends are quite smooth despite increased coverage of Lightcast data over time.





Figure 2: Evolution of low-carbon ads in the US (2010-2019)

*Notes:* In panels a) and b) the intensity of low-carbon ads is first calculated at the 6-digit SOC occupation level as the ratio between the number of low-carbon ads and the total ads in a specific 6-digit occupation, then averaged for each reported occupational grouping weighing by 6-digits employment obtained from the U.S. Bureau of Labor Statistics. Panel a) represents the evolution of the share of low-carbon ads in the entire sample, in the aggregate and for low and high skill occupations. The high skill group includes SOC codes from 11 to 29; the low skill group includes codes above 29. Each subpanel in panel b) represents the evolution of the share of low-carbon ads *within* each of the main eight low-carbon occupational groups. The solid line represent the low-carbon share weighted by BLS employment, while the dotted line represent the unweighted share directly calculated from the sample.

## Spatial variation in demand for low- and high-carbon manual jobs

One of the key challenges in delivering a “just transition” and neutralising the job killing arguments deployed by fossil fuel lobbies and climate deniers [45, 50] is to ensure that displaced

workers in energy or pollution intensive industries, particularly those in low-skilled (mostly manual) occupations, find new jobs with similar pay and working conditions. The rise in the share of low-carbon vacancies for low-skilled workers is encouraging, however, the spatial distribution is less so.

Our data shows that high-carbon manual jobs are extremely spatially concentrated around centres of coal, crude oil, gas and shale oil & gas extraction including Wyoming, West Virginia, Oklahoma and Texas and the Appalachian region, echoing previous findings [39]. This holds whether mapping average share of high-carbon vacancies (Figure 3A) or high-carbon employment shares (Figure 3B). The former better captures shale fields where there is still on-going job creation while the latter better captures jobs in constantly declining sectors/ regions like coal. Borrowing from the literature on adverse deindustrialization shocks [9, 6], the spatial concentration of fossil fuel activities amplifies the negative effects of climate policies on fossil fuel communities through negative multiplier effects.

In contrast, low-carbon vacancies are more dispersed. Locational Gini coefficient estimates are twice as high for high-carbon (0.68) as it is for low-carbon ads (0.34) (Table SI.18). Particularly in renewables generation, job location reflects natural resource endowment. We observe higher green job shares in areas with high solar (e.g. California and Nevada) and wind (e.g. Minnesota to Texas wind corridor) power potential. Studies on renewable energy report high degree of spatial concentration in green and low-carbon manual activities [47, 39] suggesting the spatial dispersion found here is driven by low-carbon jobs in areas such as buildings or transport. Low-carbon jobs in Michigan, for example, are driven by bus drivers (Table SI.1).

We document limited overlap between locations of low-carbon job creation and where job destruction is more likely to be concentrated. Table SI.16 reports that the correlation between the shares of high- and low-carbon ads is 0.122 and statistically significant at conventional level, but it halves and becomes statistically insignificant when weighted it by local population levels.

This spatial mismatch between low- and high-carbon activities implies higher reallocation costs than previously thought when focusing on renewable energy jobs only [42].

Overall, our results concur with previous evidence [50, 39] that low-carbon transition has the potential to exacerbate existing regional inequalities, because high-carbon jobs tend to cluster in poorer regions, whereas low-carbon vacancies tend to be in wealthier areas (a 1% increase in average per capita income is associated with an 0.2% increase in the low-carbon ad share and a 0.1% fall in high-carbon ads (Tables SI.14 and SI.15).

Limited employment prospects for workers in communities that are vulnerable in the face of climate change imply high reallocation costs than previously thought, but this does not necessarily undermine a “just transition”. Such workers can find jobs in other sectors or jobs indirectly created by the low-carbon transition. Still, our descriptive evidence lends support to the widespread idea that distressed fossil-fuel communities may require targeted place based policies, including retraining and reskilling policies, to successfully accomplish such transition [11].

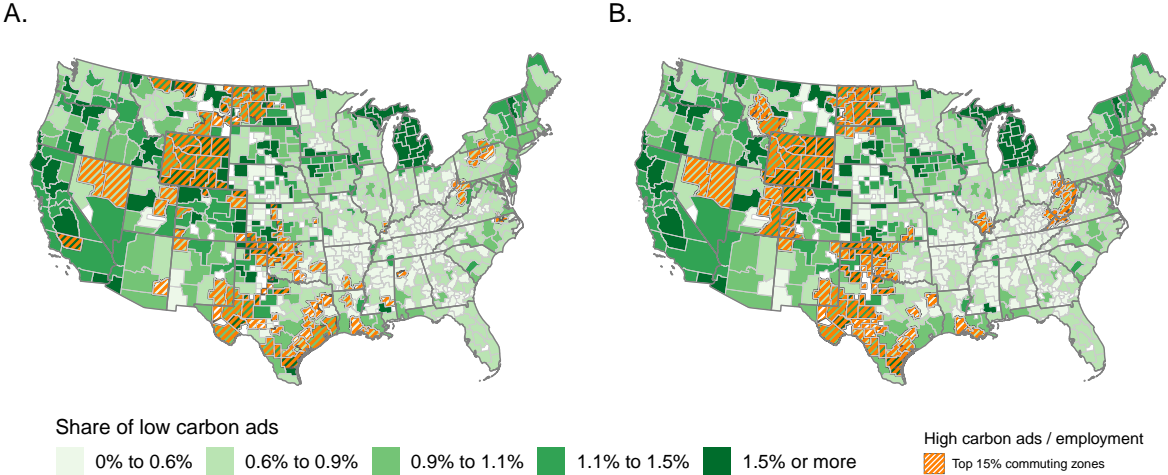


Figure 3: Spatial distribution of low-carbon vacancies and high-carbon vacancies (A) and jobs (B) in low skilled occupations

*Notes:* low-carbon vacancies and high-carbon vacancies and employment are presented for low-skilled occupations only (SOCs 31 to 53). Commuting zone level values for 2010-2019 average shares of unweighted low-carbon job ads in green shades. Commuting zones are USDA ERS delineation (2000). Hashed orange overlay indicates the commuting zones with a high share of high-carbon vacancies in panel A (top 15%, corresponding to a greater than 0.4% share of high-carbon vacancies); and high share of high-carbon employment in panel B (top 15%, 2000-2017 average, corresponding to a greater than 1.4% share of high-carbon employment. Data as used by [39] from the BLS's Occupational Employment and Wage Statistics).

## Differences in skill requirements

Previous studies examining skill similarity between occupations [25] in the green context highlight the importance of technical and managerial skills for the adoption of clean technologies [47]. To measure the skill gap more precisely, we extend this approach to the job level and assess the relative skill intensity of low-carbon vis-à-vis fossil fuel and other ads. We document low-carbon skill gaps that are larger and broader than previously found.

We focus on five broad skill groups: cognitive, IT, management, social and technical skills. These are in high demand and time-consuming to acquire: cognitive, social and managerial skills are more difficult to replace with machines [8], while IT skills complement digital technologies in the workplace [22]. Skills are classified into the five groups using a set of keywords provided by [20] except for IT skills where the Lightcast IT skill family is used (see Table SI.23) and technical skills that uses [47]. Figure 4 shows the share of low-carbon, high-carbon and generic vacancies that contain at least one (extensive margin) or more than one skill (intensive margin)(see also Table SI.20 in SI). Consistently across all 8 key occupations, low-carbon job vacancies are more likely to require skills in these 5 groups than generic jobs. The skill gap is found both at the extensive and intensive margin meaning that low-carbon ads are not only more likely to contain these skills, but also contain more of them. The low-carbon skill gap is particularly pronounced for technical, managerial, and to a lesser extent, social skills. While this confirms a technical-skill bias for green activities previously found in the literature [47, 32], our data reveal that filling gaps in IT and cognitive skills is also important for the low-carbon transition at least for a subset of occupations. The differences in skill intensity of low-carbon jobs are in most cases statistically significant at conventional levels, when regressing the low-

carbon skill gaps across Commuting Zones (Table SI.21). High-carbon jobs are also more likely to require these skill types than generic jobs, hence the skill gap is relatively narrower between low- and high-carbon ads. Still, low-carbon vacancies ask for a more complex skill portfolio than high-carbon ones for engineers (see also Table SI.21).

This study uncovers substantial heterogeneity across occupational groups that previous analyses were unable to detect. Some occupations do not follow the general pattern. Except for technical skills, no significant gaps are found for construction workers and business specialists and transportation workers. Other occupations present larger gaps, such as engineering technicians and installation and maintenance workers, indicating possible difficulties in filling low-carbon vacancies in these occupational groups. For some skills like cognitive and social, the requirement is lower for low-carbon jobs. This indicates that if low-carbon jobs are created locally, retraining coal miners to be roofer or weatherization technicians may not be exceedingly costly.

Reskilling paths vary considerably across occupational groups. To explore further heterogeneity, we use two measures of skill coreness: the green skill coreness if high indicates that a skill is relatively more important in low-carbon ads than in other ads within a given occupation, while the generic skill coreness measures how important a skill is in a particular occupation relative to other occupations (see Methods). Plotting the two indexes in Figure 5), we find a positive correlation for Engineers and Scientists indicates that reskilling paths needed to shift towards green activities in these occupations require further specialization. Further, skills contained in both low-carbon and high-carbon engineering ads belong to the core set of skills for this occupation, implying that the switch to green is easy requiring only incremental retraining. In contrast, the negative correlation for business operation specialists combined with the previous results on skill gaps suggests that here, moving into low-carbon likely involves diversifying the skill set by acquiring new technical, management or social skills that are beyond core curricula in business. No specialization-diversification patterns are found for construction workers,

architects, technicians, installation workers and transport workers, even though larger skill gaps were found for technicians and installation workers (Figure 4). This suggests that, for most of the key occupations in the low-carbon transition, retraining is likely to be highly context- and technology-specific, requiring cooperation among social actors, including trade unions, industrial associations, technical and vocational schools, to find the appropriate solutions.



Figure 4: Differences in broad skills by occupation

Notes: Each panel represents the share of ads for a given occupation and category (generic, low or high-carbon) that contains exactly one (1) or two or more (2+) skills pertaining to any of the five broad skill categories listed. Percentages reported correspond to unweighted shares of ads obtained directly from the sample. The *Cognitive*, *Management*, *Social* and *Technical* broad skills are defined using sets of keywords obtained from [20]. The *IT* broad skill corresponds to the eponymous Lightcast skill cluster family.

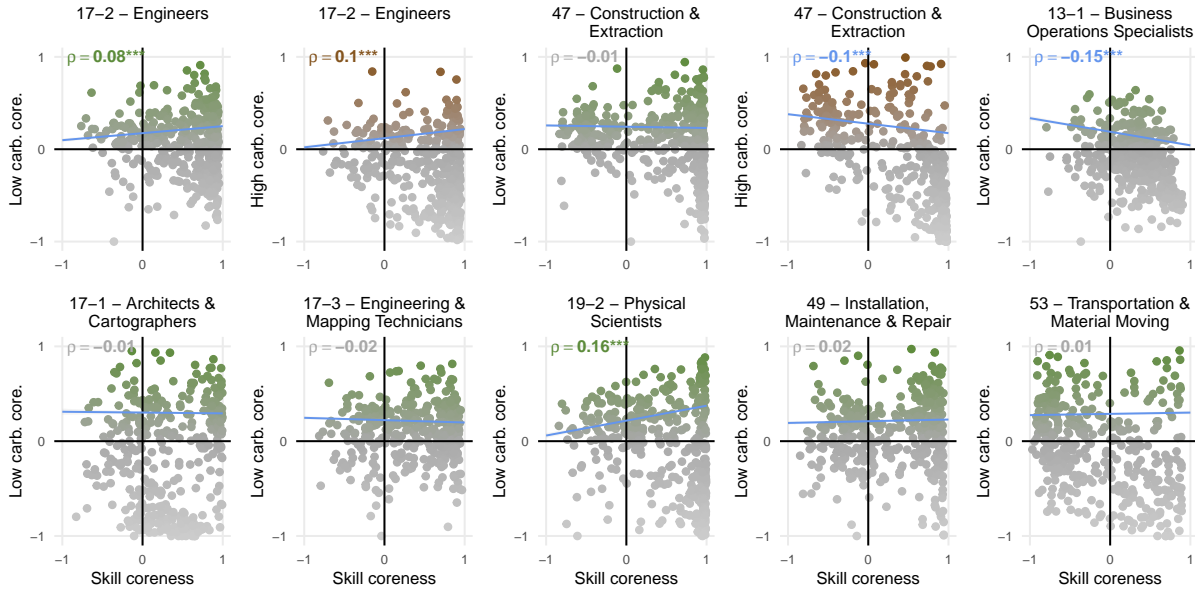


Figure 5: Specialization vs diversification by occupation

Notes: Relationship between the relative prevalence of a given skill in low (resp. high) carbon ad – low (resp. high) carbon coreness on the  $y$  axis – and its relative prevalence in the entire sample – skill coreness,  $x$  axis (see formulas below for a precise definition). Each dot represents one skill; only the 400 most frequent skills are plotted for each occupation.  $\rho$  reports the correlation between these two corenesses, obtained from a regression weighted by the share of each skill in generic ads. A significant  $\rho > 0$  indicates *specialization*: skills more prevalent in low (resp. high) carbon ads tend to be core skills of the occupation. Conversely, a significant  $\rho < 0$  indicates *diversification*: skills important in low- (resp. high-) carbon ads are not part of the occupation’s core skillset.

## The low-carbon wage premium

The wage premium depends on both labour and skill demand and supply [7]. Wage offerings thus signal potential skill mismatches and hiring difficulties, as well as the attractiveness of low-carbon jobs. Previous occupational level analyses find green jobs command a positive wage premium in the US [48] indicating that meeting higher skill requirements can yield higher earnings in greener occupations. Here, the key novelty is that we can estimate wage regressions separately for each major occupational group (see Methods).

Figure 6 reports the low-carbon wage premium for the eight occupational groups, stacking the first (2010-2012) and the last three years together (2017-2019). Importantly, what we call low-carbon wage premium only reflects a wage offer (the demand-side) and may differ from



the paid wage which is an equilibrium outcome that also accounts for supply-side factors such as the availability of candidates with required competences. Table SI.24 shows that results are qualitatively similar in richer specifications with additional covariates.

In the earlier period, there is a positive and statistically significant low-carbon wage premium coinciding with a climate policy boom associated with the American Recovery and Reinvestment Act, for all occupations except architects (17-1). We find very large premium for technicians (13%) and transport workers (16%), and a high (7%) for both installation workers and physical scientists, for which we also observe the largest skill gaps, and for business specialists (6%), possibly reflecting the difficulties to fill the gap in technical skills in such profession. For engineers, a modest (2%) premium is observed significant only at the 10% level, while a positive and non-significant premium is found for green construction vacancies.

The low-carbon premia, however, experienced a widespread and pronounced decline in more recent years. Resonating with the political turnaround in the US green policies during the Trump's era, with the withdrawal from the Paris agreement and the repeal of the Clean Power Plan, the low-carbon wage premium becomes negative and significant at the 10% level for construction workers (-2%), engineers (-4%) and transport workers (-6%). A large decline is also observed for technicians, though a positive and significant low-carbon premium is maintained in the second period (+4%). Low-carbon installation workers experience lesser reductions which may reflect the fact that repairing and maintenance tasks are in high demand after construction activities financed by the Obama era green fiscal push. Wage offers for low-carbon architects rise bucking the trend, but uncertainty is high with few low-carbon architect vacancies.

Wage premiums in high-carbon jobs are historically high due for example to resource rents and strong unions [37, 15] in contrast to low-carbon workers that are spread across the economy (see Table SI.11). We document that in both construction and engineering jobs, high-carbon

premium were indeed significantly higher than the wage offers for low-carbon ads in similar occupations at above 20%, and also declined less in the second period to around 8% for engineers and 16% for extraction workers (see SI). This is problematic for the just transition in several ways. Highly talented engineers may be absorbed by high-carbon industries, reducing the talent pool available for solving climate change problems through innovation. Even if the skill gaps can be addressed and local job opportunities are available, lower wage rates that make workers worse off will still lead to opposition to climate action.

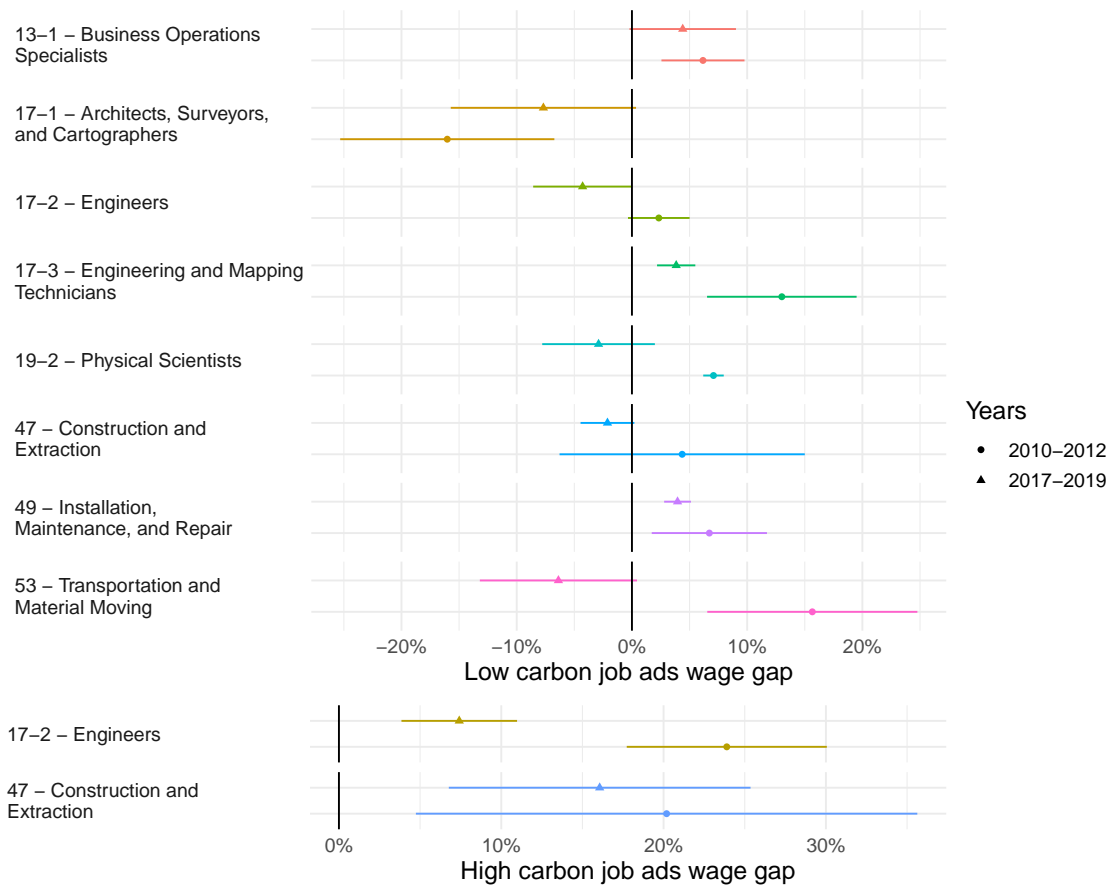


Figure 6: Wage gap between low, high-carbon and generic job ads by period

Notes: The logarithm of annual wage reported in a job ad is regressed on an indicator of whether the ad is low (resp. high) carbon while controlling for time dummies, 6-digits SOC occupation code dummies, commuting zone dummies and 2-digits NAICS industry dummies. Wages are observed in 22.5% of the ads for the 8 occupations listed, while wages and NAICS codes are observed in 10.2% – 3.2% of which are low-carbon.

## Discussion

To win support for climate policies, politicians continue to promise abundant high quality low-carbon jobs, implying improvements labour market conditions for low-skilled workers to offset some of the impacts of the ongoing digital transformation and offshoring, and selling the green transition as a vehicle to tackle rising aggregate inequality and job polarization. Yet there is scant evidence supporting such claims, in part due to the lack of credible definitions and measures of low-carbon jobs.

We offer a robust, transparent and flexible approach to accurately isolate low-carbon jobs and quantify emerging skill and wage gaps using job ads data, overcoming many of the issues with using sector or occupation-based definitions. While the backdrop of our study is that of very modest climate action – US emissions fell 8% from 5,594 to 5,144 MtCO<sub>2</sub> during our study period 2010-2019 [43] – the precise assessment of skill requirements of low-carbon activities will become even more important as massive labour reallocation towards low-carbon activities is expected under ambitious decarbonization scenarios [27, 16]. Policymakers can use our approach to monitor skill gaps associated with specific technologies and sectors that are relevant for the local economy, thus improving the effectiveness and the targeting of retraining programs. In addition, the improved evidence base on reallocation costs should be used to calibrate integrated assessment and computational general equilibrium models used to assess macroeconomic impacts of climate change mitigation.

Our most clear finding is that low-carbon vacancies systematically differ in their skill requirements. Low-carbon vacancies exhibit higher frequency of skills in all occupations, suggesting they are more skills intensive than generic job ads than previously thought [47]. Skill gaps and reskilling paths appear highly heterogeneous, suggesting that finding retraining solutions will be complex, and may need to be tailored to meet the specific needs of the companies

hiring these workers, particularly for occupational groups such as engineering technicians and installation workers.

Overall, our results suggest that reallocation cost are higher than previously considered. In addition to skill gaps, the limited geographic overlap found between low- and high-carbon jobs suggests the labour market effects of the low-carbon transition could compound existing regional disparities if low-skilled displaced workers face limited alternative employment opportunities locally. To prevent manual fossil workers being left behind, there may be a potential role for targeted place-based policies for these communities and their labour markets to adjust towards a carbon neutral world. Interpretation of our descriptive results, however, should be cautious given how little is known around the speed, extent and nature of green jobs creation in local labour markets.

We show the share of low-carbon jobs among low-skilled occupations increased during the period 2010-2019 and fell among high-skilled occupations, tentatively suggesting that the low-carbon transition could contribute to offset secular deterioration of the labour market conditions for unskilled workers. Yet low-carbon jobs no longer yield a wage premia to compensate for higher skill requirements. Reconciling this gap is a neglected but important issue for managing the low-carbon transition.

High-carbon jobs demand a similar set and high level of skills but offer markedly higher wages, and tend to be located in relatively poorer regions with strong political opposition to ambitious climate policies [42, 50]. Because demand for low-carbon activities is primarily driven by policy, the widespread decline in green wage premia in the last decade may reflect the sudden boom and bust in US climate policy. Further research is needed to uncover factors driving the inadequate wage premium found for low-carbon vacancies, to ensure a workforce fit for the low-carbon transition.

# Methods

## Identifying low-carbon ads

Accurately identifying low-carbon jobs ads is an important step to compare low-carbon and non low-carbon job ads within the same occupation. In this section we describe the three step procedure developed to identify low-carbon job ads from the near-universe sample of US online job ad data collected by Lightcast.

### *Step 1: selecting low-carbon keywords*

In a first step, drawing from [4], we select a set of valid tokenized low-carbon keywords from pre-existing and widely utilised classifications. First, the Occupational Information Network (O\*NET) dataset provides information on specific task contents of narrowly defined occupations (867 BLS Standard Occupational Classification (SOC) occupations), indicating tasks that are considered ‘green’. Examples of the textual descriptions of tasks include:

- “Prepare or present technical or project status reports.”
- “Calibrate vehicle systems, including control algorithms or other software systems.”
- “Measure and mark cutting lines on materials, using a ruler, pencil, chalk, and marking gauge.”

The definition of ‘green’ tasks, which was added to the dataset under the Green Economy Program of 2009, covers not only climate change related tasks, but also tasks that contribute towards non-climate environmental problems such as waste management, remediation activities, and activities associated with local air and water pollution<sup>1</sup>. We utilise a complementary sector classification (SOC 6-digit level) to isolate the tasks relevant to CO<sub>2</sub> mitigation or adaptation, from general green activities. Specifically, we select only a subset of green specific

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<sup>1</sup>See <https://www.onetcenter.org/reports/GreenTask.html> for more details.

tasks performed in the following green sectors: “Agriculture and Forestry”, “Energy and Carbon Capture and Storage”, “Energy Efficiency”, “Energy Trading”, “Environment Protection”, “Governmental and Regulatory Administration”, “Green Construction”, “Manufacturing”, “Renewable Energy Generation”, “Research, Design, and Consulting Services”, “Transportation”. Examples of low-carbon green tasks in O\*NET include:

- “Calculate potential for energy savings.”
- “Fabricate prototypes of fuel cell components, assemblies, or systems.”
- “Test wind turbine components, by mechanical or electronic testing.”

while non low-carbon green tasks include:

- “Monitor and adjust irrigation systems to distribute water according to crop needs and to avoid wasting water.”
- “Prepare hazardous waste manifests or land disposal restriction notifications.”
- “Advise land users, such as farmers or ranchers, on plans, problems, or alternative conservation solutions.”

‘To extract keywords from these O\*NET task descriptors, we first tokenize them, keeping only nouns, adjectives, verbs and adverbs. We then apply natural language processing (NLP) using the term frequency–inverse document frequency (TF-IDF) algorithm [34] on the low-carbon and non low-carbon subsets of tasks in O\*NET. This yields a score indicating how relevant each word is to low-carbon tasks and products.. For each keyword in the low-carbon subset, we then take the difference in the relevance score obtained within the low-carbon subset of tasks ( $s_g$ ) and the one obtained in the non low-carbon subset ( $s_{ng}$ ), normalizing to a zero score for words that only appear in one of the two lists. This step provides us with a low-carbon

likelihood (LCL) for each keyword appearing in the O\*NET task descriptions. In particular,  $LCL = s_g - s_{ng}$ . The LCL measures the extent to which each keyword is specific to low-carbon tasks rather than being a general characteristic describing the occupational task content. Obviously, negative value of the LCL index are assigned to keywords not characterising low-carbon activities, while positive LCL are indicates relevance for such activities.

We apply a similar approach to the PRODCOM classification by contrasting the textual descriptions of climate change mitigation relevant products identified by [13] with that of other products.

Examples of low-carbon products in PRODCOM include:

- “Frames and forks, for bicycles”
- “Multiple-walled insulating units of glass”
- “Vehicles with an electric motor”

We then combine the two lists and sort them by the LCL index defined above. We keep the top 250 of these to get a set of *low-carbon* (climate-related) keywords. The LCL index is distributed as a steeply decreasing power law, becoming essentially flat beyond rank 30. Thus the exact choice of cutoff does not substantially affect the results of our classification exercise. Limiting the total number of keywords used to 250 is further motivated by computational considerations, as matching against a list of keywords increases quadratically with the number of words in the list.

*Step 2: Mapping low-carbon keywords with Lightcast job identifiers*

We proceed to map our list of 250 low-carbon keywords against the 16,059 unique skills present in the Lightcast dataset, to identify a subset of low-carbon skills /job identifiers. To do so, we use the natural language processing algorithm Word2Vec [41] to semantically match

each job identifier word against our 250 low-carbon keywords, yielding a “low-carbon matching score” for each job identifier.

Semantic matching with word embeddings (such as Word2Vec) is more robust than more naïve, string-based / fuzzy matching approaches (e.g. using ‘wind\*’ to match both ‘wind power’ and ‘wind mill’). For example, ‘solar’ and ‘photovoltaics’ are recognized as being semantically similar, even though they would be considered unrelated with naïve fuzzy matching. Word embeddings rely on a language model trained on a corpus of text to identify semantic similarities between words, based on their patterns of co-occurrence with other words (e.g. the model will pick up from observing “The king rules the country”, “The queen rules the land”, and “The prince governs the county” that ‘king’, ‘queen’ and ‘prince’ are close semantically). Each word is thus represented as a vector in this feature space. The generalized cosine distance in that vector space measures semantic proximity. Here we use the pre-trained word embedding model provided by Google for the English language, Word2Vec, trained on the Google News dataset, which comprises around 100 billion words. At a mathematical level, each word is projected onto a number of dimensions (called the feature space, numbering a few hundreds in the case of Word2Vec). The power of this approach resides in the fact that, like many deep learning techniques, it is unsupervised: the feature space doesn’t need to be designed by the implementer, and is instead built endogenously by the model.

To increase the robustness of the procedure against the choice of cutoff in the first step, we re-weight the matching score using the individual keywords’ LCL. We automatically retain those Lightcast job identifiers that achieve a direct string match against one of the top 20 low-carbon keywords collected in the first step. For instance, the keyword ‘solar’ matches the Lightcast identifier ‘Solar Engineering’ directly. These form our initial 396 low-carbon job identifiers and this unsupervised portion of our classification algorithm excludes 15,063 potential identifiers that match none of our low-carbon keywords. This leaves 600 ambiguous matches with a



high yet imperfect matching score. These cases cannot be settled by our unsupervised classifier. We therefore turn to an expert survey.

*Step 3: Expert survey*

To resolve ambiguous cases, we asked experts in the field of climate change to classify job identifiers as low-carbon or not through an online survey. Responses were obtained from 50 climate experts at leading institutions including Oxford University, the London School of Economics, the OECD and the University of Venice (invitation email presented below).

Each expert was tasked to designate 120 job identifiers as low-carbon or non-low-carbon. Of these job identifiers, 100 were randomly sampled from the set of 600 ambiguous identifiers described above, while 20 were sampled from the 396 low-carbon identifiers found through a perfect match with our low-carbon keywords. The latter subset was included to verify the quality of the expert's classification skills as well as to corroborate the previous step of the procedure.

We exclude responses from experts that did not correctly classify at least 40% of these placebo identifiers. We then combine these returns to calculate an average low-carbon score for each identifier surveyed using the following scoring scheme: 1 for 'Yes', 0.25 for a blank response, and 0 for 'No'. We finally apply a threshold score of 0.9 to obtain a further 49 low-carbon job identifiers.

This three-steps procedure gives a list of 445 low-carbon skills that we use as low-carbon job identifiers. A vacancy posing is considered low-carbon if it contains at least one low-carbon job identifier. The list of low-carbon related skills is made available with this publication to advance research and analyses in this area.

## The Lightcast dataset

Lightcast uses web scraping to collect data on job posting from approximately 50,000 online job boards as well as company websites [31], removes duplicates and parses into a systematic, usable format. For each job ad, Lightcast extracts job characteristics information including occupation, educational qualifications requirements, skills, employer characteristics, location and wage. Lightcast data thus allows us to observe changes in skill requirement at the job level, and compare similar jobs within the same occupation, improving the granularity of analysis relative to previous work looking at changes in the task content at the occupation level.

Lightcast extracts around 16,000 unique skills (job identifiers) from job ads, which is a canonicalised version of skills contained in the job ads. A large portion of these skills (6,959 or 44%) are also assigned a skill cluster (groupings of skills that have similar functionality) and a skill cluster family (the most general layer of the Lightcast skill taxonomy). For example, the skill “smart grid” belongs to the skill cluster “electrical construction” in the skill family “architecture and construction”.

Figure SI.1 shows the average number of skills listed per job ad over time and job category (generic, high-carbon and low-carbon). The number of skills per position advertised has trended upwards over the period of observation across all job categories, with the median skill count growing from 6 to 8 from 2010 to 2019. The number of skills contained in low-carbon vacancies has been consistently higher over the entire decade, reaching a median value of 12 skills per low-carbon ads in 2019, compared with 8 for generic ads and 9 for high-carbon ads.

Variation in skill vector length in general, and the longer skill vector length for low-carbon job ads specifically may be attributed to a number of factors. First, more complex jobs contain more skills in ads. It could also be attributed to marketing strategies of firms trying to attract talent to low-carbon jobs by providing excessively detailed job descriptions to partly offset low wage offers – which we do not observe. More skills may be found in postings for new job

types – new, unfamiliar low-carbon positions may be described in more detail to ensure a good candidate match, compared to the average job.

Figure SI.2 highlights the heterogeneity in skill vector lengths across major occupational groups. As expected, on average in 2019, more skills are contained in high skilled job ads (e.g. 17 - Architects & Engineers and 19 - Scientists) with a median of 10 skills per ad, than in low skilled job ads (e.g. 47 - Construction & Extraction and 49 - Installation, Maintenance & Repair) with a median of 7 skills per ad.

## Wage regressions

We estimate wage regressions [35] separately for each major occupational group to retrieve the low-carbon wage premium, we estimate the following equation at the job ad level ( $i$ ) separately for the first (2010-2012) and the last period (2017-2019), and by the eight main occupational groups considered in our analysis:

$$\log(w_{it}) = \beta_{lc} \mathbb{1}\{i \in lc\} + \sum_k \mu_k + \alpha_t + \varepsilon_i$$

where  $w_{it}$  is the annual wage as posted in the ad. Wage is logged to mitigate the influence of outliers. We are interested in estimating the returns to low-carbon ad in a specific occupation, that is:  $\beta_{lc}$ , conditional on a set of controls. Controls  $\mu_k$  include occupation (6-digit SOC), industry (2-digit NAICS) and commuting zones, respectively. These controls purge the low-carbon wage premium from the influence of obvious confounders, such as unobserved industry-level and regional shocks. Moreover, we control flexibly for the length of the skill vector in the job ad using a set of five dummy variables for a corresponding number of skill vector length bins (1-4, 5-8, 9-12, 13-16, 17+). Together with a set of dummies indicating the education level required in the ad, these controls capture both the complexity of the job post and the differences in advertising styles across companies.

Wage information are available for approximately 20% of job ads, thus, to mitigate concerns related to the representativeness of our estimation sample, we weight regressions by the BLS employment of the 6-digit occupation. Unfortunately, the number of job ads with missing information on education and sector is very large reducing the size of the estimation sample by 65% and 55%, respectively. We thus use a parsimonious specification with only years, occupation, CZ and job length dummies in the main specification, while testing the robustness of our results to the inclusion of additional controls. Finally, to limit the influence of outliers, we exclude ads comprising more than 100 skills.

Slightly abusing of terminology, what we call low-carbon wage premium only reflects a wage offer (the demand-side) and may differ from the actually paid wage which is an equilibrium outcome that also accounts for supply-side factors such as the availability of candidates with required competences. [20] and [5] circumvent this problem by combining BLS wage data with skill data extracted from job ads at the occupational level. However, such approach would only allow estimating an average low-carbon wage premium, exploiting cross-occupational variation in green tasks as in [48]. To complement such approach, we thus decide to estimate occupational-specific differences in wage offers between low-carbon and generic job ads.

Our estimate of the low-carbon wage premium cannot be interpret as a causal impact of switching to low-carbon activities on wages. Because we only observe the wage posted in the ad and not the actual wage paid when the vacancy is filled, unobserved workers' skills are not a main additional source of estimation bias here. In turn, we are well aware that unobserved firm characteristics are highly correlated with the wage offered, but including firm fixed effects is unfeasible since it implies dropping too many observations from a relatively small sample. If larger companies are more likely to advertise low-carbon ads and have market power so pay higher wages on average, the low-carbon premium is an upper bound. Vice versa, the

low-carbon premium is a lower bound if green companies are smaller than non-green companies. While there is some evidence that wind and solar generation is concentrated in small and medium sized establishments [38], it is not enough to argue that our estimates of the low-carbon wage premium are downwardly biased.

**Data availability statement.** The job ads data used in this research was provided by Lightcast. The contractual agreement restricts public posting of the data set. The dataset can however be purchased from Lightcast.

**Code availability statement.** Code for data cleaning and analysis is provided as part of the replication package. It will be uploaded on the Corresponding Author's Github public profile once the paper has been conditionally accepted. [INSERT LINK HERE CONDITIONAL ON PAPER BEING ACCEPTED.]

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## Supplementary Information

### Definition of low-carbon ads

The three-step process described yields 445 low-carbon identifiers in total. We define low-carbon job ads as those that contain *at least* one of the 445 low-carbon job identifiers.

Table SI.1 presents examples of low-carbon job ads and informations contained in it including location, degree and annual wage. The last column contains examples of Lightcast skills, highlighting the low-carbon identifier in bold. Non low-carbon skills are important for the analysis of section where we compare the skill sets of low-carbon to other ads within the same occupation.

To give some intuitive insights on the methodology, Table SI.2 lists the top 50 low-carbon identifiers. Besides bus driving, insulation, energy efficiency (or conservation) and renewable energy stand out as the most frequent identifiers. Note the inclusion of several identifiers related to building retrofitting and weatherization that were heavily subsidized under the green ARRA program [39].

Table SI.1: Example of low-carbon ads

| Title   | SOC  | Location                     | Degree      | Annual wage | Skills  |
|---|--|------------------------------|-------------|-------------|---|
| Senior Planner                                      | 13-1121 - Meeting, Convention, and Event Planners                  | Upper Marlboro, Maryland     | Master's    | 51k - 88k   | <b>Bicycle Planning</b> , Editing, Environmental Science, Grant Applications, Planning, Transit-Oriented Development, Writing   |
| Facilities Planner                                  | 17-1011 - Architects, Except Landscape and Naval                   | Tallahassee, Florida         | Bachelor's  | 35k - 40k   | <b>Green Building</b> , Budgeting, Capital Planning, Construction Management, Planning, Project Management, Spreadsheets, Urban Planning  |
| Chemical Engineer                                   | 17-2041 - Chemical Engineers                                       | Houston, Texas               | Bachelor's  | 180k - 200k | <b>Energy Efficiency</b> , Business Acumen, Chemical Engineering, Performance Appraisals, Process Modeling, Project Management, Simulation, Technical Support   |
| Printer/Electronics Technician                      | 17-3023 - Electrical and Electronics Engineering Technicians       | Denver, Colorado             | Associate's | 51k - 51k   | <b>Retrofitting</b> , AC/DC Drives and Motors, Break/Fix, Computer Literacy, Description and Demonstration of Products, Fault Codes, Lifting Ability, Mechanical Repair, Microsoft Office, Printers, Repair, Troubleshooting  |
| Post-Doctoral Research Scholar-Chemical Engineering | 19-2011 - Astronomers  | Richmond, Virginia           | PhD         | 59k - 85k   | <b>Green Chemistry</b> , Chemical Engineering, Chemistry, Communication Skills, Design of experiments (DOE), High-Performance Liquid Chromatography (HPLC), Lab Safety, Laboratory Safety And Chemical Hygiene Plan, Mentoring, Research, Teamwork / Collaboration, Writing |
| Lead Solar Installer                                | 47-2231 - Solar Photovoltaic Installers                            | Rancho Cucamonga, California | High School | 37k - 41k   | <b>Solar Installation</b> , Customer Contact, Electrical Experience, Fall Protection, Operations Management, Physical Abilities, Roofing, Scheduling  |
| Maintenance Mechanic                                | 49-9099 - Installation, Maintenance, and Repair Workers, All Other | Battle Creek, Michigan       | High School | 19k - 26k   | <b>Energy Efficiency</b> , Commercial Driving, Repair, Troubleshooting Technical Issues   |
| Driver  | 53-3032 - Heavy and Tractor-Trailer Truck Drivers                  | Sterling Heights, Michigan   | High School | 120k - 120k | <b>Bus Driving</b> , Over The Road, Repair, Truck Driving   |

Table SI.2: Top 50 low-carbon identifiers most commonly observed in job ads

| Low carbon identifier        | Ad count | Low carbon identifier           | Ad count |
|------------------------------|----------|---------------------------------|----------|
| Bus Driving                  | 210,459  | Efficient Transportation        | 21,115   |
| Insulation                   | 177,865  | Public Transit Systems          | 20,825   |
| Energy Efficiency            | 156,830  | Emissions Testing               | 20,335   |
| Energy Conservation          | 128,151  | Pollution Control               | 20,247   |
| Renewable Energy             | 127,146  | Fuel Cell                       | 19,596   |
| Retrofitting                 | 89,088   | Electric Vehicle                | 19,281   |
| Solar Energy                 | 58,834   | Energy Reduction                | 18,412   |
| Climate Change               | 43,228   | Insulation Installation         | 18,066   |
| Clean Energy                 | 37,395   | Alternative Fuels               | 16,793   |
| Solar Sales                  | 36,795   | Clean Air Act                   | 16,546   |
| Pollution Prevention         | 32,959   | Geothermal                      | 16,480   |
| Environmental Sustainability | 32,856   | Greenhouse Gas                  | 15,521   |
| Air Emissions                | 31,452   | Solar Installation              | 14,725   |
| Wind Power                   | 31,272   | Federal Railroad Administration | 14,647   |
| Wind Turbines                | 29,202   | Sustainable Energy              | 13,922   |
| Photovoltaic (PV) Systems    | 26,249   | Green Energy                    | 13,462   |
| Alternative Energy           | 25,997   | Energy Conservation Measures    | 13,200   |
| Smart Grid                   | 25,725   | Solar Systems                   | 12,980   |
| Sustainable Design           | 24,826   | Weatherization                  | 12,842   |
| Fuel Efficiency              | 24,550   | Air Permitting                  | 12,750   |
| Solar Panels                 | 24,316   | Biomass                         | 12,081   |
| Air Pollution Control        | 24,184   | Energy Policy                   | 11,558   |
| Ethanol                      | 23,026   | Solar Consultation              | 10,630   |
| Light Rail                   | 21,560   | Clean Technology                | 10,466   |
| Green Building               | 21,442   | Emissions Management            | 10,092   |

## Expert survey email

*Dear [Expert name],*

*With [coauthor] and [coauthor], I am currently working on a project to identify the competencies necessary in the transition to a zero-carbon economy from an exhaustive dataset of all online job vacancies in the US over the past decade.*

*One major step involves the definition of what is a low-carbon job ad among millions of possible job vacancies. We have applied Natural Language Processing techniques to automate the selection of low-carbon job vacancies starting from a predefined set of clean energy keywords from previous research on the topic. By "low-carbon" we mean an activity that reduces GHG emissions in several sectors: agriculture and forestry; power generation, storage and distribution; energy efficiency; manufacturing; transport; building and construction; engineering; research, design & consulting; regulation.*

*However, we need an expert review for a subset of identifiers that are ranked by the algorithm as "low-carbon", but only marginally so.*

*Would you be willing to review the attached list of 125 attributes of a job vacancy and label those you consider to be "low-carbon" according to your own expert knowledge?*

*Many thanks for your help!*

*Kind regards,*



Table SI.3: low-carbon job identifiers/ low-carbon skills

|                                   |   |                                   |
|-----------------------------------|---|-----------------------------------|
| Air Emissions                     | Biomass Research                          | Building Energy Modeling (BEM)    |
| Air Permitting                    | Biomass Thermochemical Conversion         | Direct Methanol Fuel Cells        |
| Air Pollution Control             | Biomass Transformation                    | Directed Energy Systems           |
| Air Quality Control               | Biorefinery                               | Dressing Changing                 |
| Air Quality Regulations           | Building Energy Codes                     | EPA Regulation                    |
| Air Quality Remediation           | Building Energy Modeling Software         | Efficient Transportation          |
| Air Quality Standards             | Building Envelope Evaluation              | Electric Car Industry Knowledge   |
| Alternative Air Conditioning      | Bus Driving                               | Electric Vehicle                  |
| Alternative Energy                | Bus Industry Knowledge                    | Emission Reduction Projects       |
| Alternative Energy Design         | Bus Kneeling Systems                      | Emissions Analysis                |
| Alternative Energy Evaluation     | Bus Safety                                | Emissions Analyzer Operation      |
| Alternative Fuel Vehicles         | Carbon Accounting                         | Emissions Analyzers               |
| Alternative Fuels                 | Carbon Asset Management                   | Emissions Control Systems         |
| Alternative Transportation        | Carbon Dioxide Flooding                   | Emissions Inspection              |
| Automatic Insulation Strippers    | Carbon Emissions Reduction                | Emissions Inventories             |
| Automotive Energy Management      | Carbon Footprint                          | Emissions Management              |
| Bicycle Planning                  | Carbon Footprint Reduction                | Emissions Mitigation              |
| Bike Industry Knowledge           | Carbon Management                         | Emissions Monitoring              |
| Bike Repair                       | Carbon Offsets                            | Emissions Reduction               |
| Biodiesel                         | Carbon Reduction                          | Emissions Reduction Strategy      |
| Biodiesel Development             | Clean Air Act                             | Emissions Standards               |
| Biodiesel Industry Knowledge      | Clean Energy                              | Emissions Testing                 |
| Biodiesel Production              | Clean Technology                          | Energy - Efficient Systems        |
| Biodiesel Research                | Clean Technology Investment Opportunities | Energy Conservation               |
| Biodiesel Technology              | Cleantech Products                        | Energy Conservation Measures      |
| Biofuel Product Development       | Climate Analysis                          | Energy Cost Reduction             |
| Biofuel Production                | Climate Change                            | Energy Efficiency                 |
| Biofuels Applications             | Climate Change Analysis                   | Energy Efficiency Analysis        |
| Biofuels Development              | Climate Change Impact                     | Energy Efficiency Assessment      |
| Biofuels Extraction               | Climate Change Mitigation Initiatives     | Energy Efficiency Consultation    |
| Biofuels Plant Safety             | Climate Change Policies                   | Energy Efficiency Improvement     |
| Biofuels Processing               | Climate Change Principles                 | Energy Efficiency Products        |
| Biofuels Processing Equipment     | Climate Change Processes                  | Energy Efficiency Research        |
| Biofuels Production Adjustment    | Climate Change Programs                   | Energy Efficiency Services        |
| Biofuels Production Management    | Climate Change Research                   | Energy Efficiency Supervision     |
| Biofuels Quality Assessment       | Climate Change Simulations                | Energy Efficiency Technologies    |
| Biofuels Research                 | Climate Data Analysis                     | Energy Efficient Building         |
| Biofuels Research and Development | Climate Information                       | Energy Efficient Home Improvement |
| Biofuels Technology               | Climate Management Research               | Energy Efficient Lighting         |
| Biomass                           | Climate Outreach                          | Energy Efficient Operations       |
| Biomass Conversion                | Climate Policy                            | Energy Efficient Transportation   |
| Biomass Determination             | Climate Prediction                        | Energy Loss Reduction             |
| Biomass Equipment                 | Climate Research                          | Energy Measurement Devices        |
| Biomass Feedstock Measurement     | Climate Systems                           | Energy Policy                     |
| Biomass Fuel Gasification Systems | Climate Theory                            | Energy Reduction                  |
| Biomass Gasification Processes    | Commercial Solar Projects                 | Energy Saving Plumbing Systems    |
| Biomass Plant Equipment           | Commercial Solar Sales                    | Energy Saving Products            |
| Biomass Power Production          | Concentrated Photovoltaic Technology      | Energy Savings Calculations       |
| Biomass Processing Equipment      | Cooling Efficiency                        | Energy Star Documentation         |
| Biomass Production                | Dam Construction                          | Energy Supply Side Savings        |

Table SI.4: low-carbon job identifiers/ low-carbon skills (cont.)

|   |  |   |
|---|--|---|
| Energy Usage Tracking                         | Green Energy Promotion                   | Light Rail                              |
| Energy-Efficient Appliances                   | Green Job Development                    | Light Rail Transit Systems              |
| Environmental Sustainability                  | Green Manufacturing                      | Locomotive Engineering                  |
| Ethanol                                       | Green Marketing                          | Locomotive Inspection                   |
| FRET (Fluorescence Resonance Energy Transfer) | Green Plumbing                           | Locomotive Safety                       |
| Federal Railroad Administration               | Green Plumbing Equipment Installation    | Loose Insulation                        |
| Federal Transit Administration                | Green Procurement                        | Low Carbon Projects                     |
| Fuel Cell                                     | Green Real Estate                        | Low Carbon Solutions                    |
| Fuel Cell Analysis                            | Green Retail                             | Low Energy Buildings                    |
| Fuel Cell Applications                        | Green Retrofitting                       | Mass Transit Industry Knowledge         |
| Fuel Cell Assembly                            | Green Roof Design                        | Methane Gas Collection System           |
| Fuel Cell Design                              | Green Roof Installation                  | Methane Monitors                        |
| Fuel Cell Development                         | Green Roofing                            | Mitigation Projects                     |
| Fuel Cell Engineering                         | Green Stocks                             | Monorail                                |
| Fuel Cell Generator                           | Green Strategy                           | Non-Point Source Pollution              |
| Fuel Cell Modeling                            | Green Supplier                           | Organic Photovoltaics (OPV)             |
| Fuel Cell Performance Improvement             | Green Techniques                         | PV System Design and Drafting           |
| Fuel Cell Research                            | Green Technology                         | Photovoltaic (PV) Energy Production     |
| Fuel Cell System Design                       | Green Transportation                     | Photovoltaic (PV) Equipment             |
| Fuel Cell Testing                             | Green Walls                              | Photovoltaic (PV) Systems               |
| Fuel Cell Testing Equipment                   | Greenhouse Gas                           | Photovoltaic Energy                     |
| Fuel Cell Theory                              | Greenhouse Gas (GHG) Emissions           | Photovoltaic Solutions                  |
| Fuel Cell Validation                          | Greenhouse Gas Accounting                | Photovoltaic System Design              |
| Fuel Cell Vehicles                            | Hazardous Energy Control                 | Photovoltaic (PV) Module Evaluation     |
| Fuel Efficiency                               | Heat Pump Installation                   | Pipe Insulation                         |
| Geothermal                                    | Heat Pump Maintenance                    | Plumbing Pipe Insulation                |
| Geothermal Energy Plants                      | Heat Pump Repair                         | Pollution Control                       |
| Geothermal Heat Systems                       | Heavy Rail                               | Pollution Control Equipment             |
| Geothermal Loop Systems                       | Heavy Rail Transit Systems               | Pollution Control Systems               |
| Geothermal Plant Equipment                    | High Speed Rail                          | Pollution Prevention                    |
| Geothermal Plant Operations                   | Home Energy Assessment                   | Pollution Regulation                    |
| Geothermal Production                         | Home Energy Rating                       | Pollution Source Identification         |
| Geothermal Production Management              | Hybrid Buses                             | Pollution Underwriting                  |
| Geothermal Sales                              | Hybrid Vehicle                           | Polymer Electrolyte Membrane Fuel Cells |
| Global Warming                                | Hydroelectric Power                      | Public Transit Operations               |
| Global Warming Pollution                      | Hydrogen Production                      | Public Transit Systems                  |
| Green Architecture                            | Hydropower                               | Public Transportation                   |
| Green Automotive Technologies                 | Hydropower Plant Equipment               | Public Transportation System            |
| Green Building                                | Hydropower Technology                    | Rail Bridge Design                      |
| Green Building Standards                      | Installing LED Lighting                  | Rail Equipment Maintenance              |
| Green Certified Construction Practices        | Insulation                               | Rail Equipment Repair                   |
| Green Chemistry                               | Insulation Efficiency                    | Rail Industry Knowledge                 |
| Green Chemistry Methods                       | Insulation Installation                  | Rail Operations                         |
| Green Communities                             | Landfill Design                          | Rail Safety                             |
| Green Contractor                              | Landfill Gas Collection                  | Rail-Track Laying                       |
| Green Design                                  | Landfill Gas Collection System Operation | Railroad Conducting                     |
| Green Distributor                             | Landfill Inspection                      | Railroad Design                         |
| Green Education                               | Landfill Operations                      | Railroad Engineering                    |
| Green Energy                                  | LEED                                     | Railroad Law                            |
| Green Energy Marketing                        | LEED Rating System                       | Railroad Operating Rules                |

Table SI.5: low-carbon job identifiers/ low-carbon skills (cont.)

|                                      |  |  |
|--------------------------------------|--|--|
| Railroad Safety                      | Solar Farm                                 | Sustainable Living                     |
| Railway Signaling                    | Solar Heat Absorption Reduction            | Sustainable Manufacturing              |
| Railway Systems                      | Solar Heating                              | Sustainable Materials                  |
| Renewable Energy                     | Solar Hot Water Heating Systems            | Sustainable Packaging                  |
| Renewable Energy Consultation        | Solar Installation                         | Sustainable Systems                    |
| Renewable Energy Development         | Solar Manufacturing                        | Tidal Power                            |
| Renewable Energy Equipment           | Solar Module Assembly                      | Trams                                  |
| Renewable Energy Industry Knowledge  | Solar Panel Assembly                       | Waste - to - Energy Conversion Systems |
| Renewable Energy Installation        | Solar Panel Attachment                     | Waste-to-energy                        |
| Renewable Energy Markets             | Solar Panel Fitting                        | Water Pollution Control                |
| Renewable Energy Supply              | Solar Panels                               | Water Pollution Source Identification  |
| Renewable Energy Systems             | Solar PV Generation Systems                | Weatherization                         |
| Renewable Resources                  | Solar PV Hot Water Heating Systems         | Weatherization Installation            |
| Renewable Sales                      | Solar Photovoltaic Business Development    | Wind Commissioning                     |
| Residential Energy Auditing          | Solar Photovoltaic Design                  | Wind Consultation                      |
| Residential Energy Conservation      | Solar Photovoltaic Engineering             | Wind Energy Engineering                |
| Residential Energy Efficiency        | Solar Photovoltaic Installation            | Wind Energy Industry Knowledge         |
| Residential Energy Sales             | Solar Photovoltaic Panels                  | Wind Energy Operations                 |
| Retrofitting                         | Solar Photovoltaic Performance Improvement | Wind Energy Operations Management      |
| Roof Insulation Surfaces             | Solar Photovoltaic Research                | Wind Energy Project Management         |
| Rubber Dam Placement                 | Solar Photovoltaic Technology              | Wind Energy Project Planning           |
| Rubber Dam Removal                   | Solar Power Electrical Work                | Wind Farm Analysis                     |
| Self-Adjusting Insulation Stripper   | Solar Power Purchase Agreement Sales       | Wind Farm Construction                 |
| Silicon Solar Cell                   | Solar Power System Design                  | Wind Farm Design                       |
| Smart Grid                           | Solar Products                             | Wind Field Operations                  |
| Smoke Emissions Reduction            | Solar Purchasing Management                | Wind Generator Assembly                |
| Solar Application                    | Solar Roofing System Installation          | Wind Integration Studies               |
| Solar Array Production Calculation   | Solar Roofs                                | Wind Measurement                       |
| Solar Boilers                        | Solar Sales                                | Wind Power                             |
| Solar Cell                           | Solar Sales Management                     | Wind Power Development                 |
| Solar Cell Design                    | Solar Start Ups                            | Wind Project Construction              |
| Solar Cell Equipment                 | Solar Systems                              | Wind Project Development               |
| Solar Cell Manufacturing             | Solar Technology                           | Wind Project Engineering               |
| Solar Cell Manufacturing Equipment   | Solar Thermal Installation                 | Wind River                             |
| Solar Collector Installation         | Solar Thermal Systems                      | Wind Turbine Construction              |
| Solar Consultation                   | Solar and Wind Energy                      | Wind Turbine Control System            |
| Solar Contractor                     | Spray Foam (Insulation)                    | Wind Turbine Equipment                 |
| Solar Design                         | Sungard Energy                             | Wind Turbine Equipment Testing         |
| Solar Development                    | Sustainability Campaigns                   | Wind Turbine Fabrication               |
| Solar Electric Installation          | Sustainability Consulting                  | Wind Turbine Performance Improvement   |
| Solar Energy                         | Sustainability Evaluation                  | Wind Turbine Production                |
| Solar Energy Components              | Sustainability Improvement                 | Wind Turbine Service                   |
| Solar Energy Industry Knowledge      | Sustainability Marketing                   | Wind Turbine Technology                |
| Solar Energy Installation Management | Sustainability Procedures                  | Wind Turbines                          |
| Solar Energy System Development      | Sustainability Research                    | Zero- Energy Buildings                 |
| Solar Energy System Installation     | Sustainable Agriculture                    |  |
| Solar Energy Systems                 | Sustainable Architecture                   |  |
| Solar Energy Systems Engineering     | Sustainable Design                         |  |
| Solar Engineering                    | Sustainable Energy                         |  |
| Solar Equipment                      | Sustainable Engineering                    |  |

## **Representativeness of the Lightcast dataset**

Burning Glass data aims to be a near-universe of online job postings and is increasingly used in research. However, it is also well known that it over-represents growing firms [19] and certain occupations such as business & financial, computer & mathematical, and healthcare occupations and under-represents construction, public administration & government, mining & logging, and accommodation & food services[31]. Further, online job vacancies data capture changes in labour demand, rather than the stock of employment population. A 1.35% share of new low-carbon vacancies is equal to a steady state stock of low-carbon jobs only if: i. The job filling rate is equal to 1; ii. The job destruction rate is the same for low-carbon and non low-carbon occupations.

Growing firms or occupations are over-represented and many jobs are not posted online, including self-employment. In our analyses, we partially restore representativeness by re-weighting low-carbon jobs using BLS employment shares (Table SI.6). Our estimate on low-carbon jobs are in the ballpark of previous estimates of the share of green jobs [12, 23, 48, 39] though on the lower end, which can be attributed to the focus on low-carbon activities excluding green activities such as water and waste.

Table SI.6: Representativeness of Burning Glass Technologies ads dataset vs. BLS employment

| SOC major group                                     | Ad count   | Unweighted ad share | BLS employment share |
|---|------------|---------------------|----------------------|
| 11 - Management                                     | 22,716,404 | 12.0%               | 5.0%                 |
| 13 - Business and Financial Operations              | 13,035,329 | 6.9%                | 5.1%                 |
| 15 - Computer and Mathematical                      | 22,438,181 | 11.9%               | 2.9%                 |
| 17 - Architecture and Engineering                   | 6,073,207  | 3.2%                | 1.8%                 |
| 19 - Life, Physical, and Social Science             | 1,946,038  | 1.0%                | 0.8%                 |
| 21 - Community and Social Service                   | 2,178,888  | 1.2%                | 1.4%                 |
| 23 - Legal  | 1,572,981  | 0.8%                | 0.8%                 |
| 25 - Education, Training, and Library               | 5,119,425  | 2.7%                | 5.8%                 |
| 27 - Arts, Design, Entertainment, Sports, and Media | 4,629,983  | 2.5%                | 1.3%                 |
| 29 - Healthcare Practitioners and Technical         | 23,327,278 | 12.4%               | 5.9%                 |
| 31 - Healthcare Support                             | 4,025,828  | 2.1%                | 2.9%                 |
| 33 - Protective Service                             | 2,016,089  | 1.1%                | 2.5%                 |
| 35 - Food Preparation and Serving Related           | 6,985,491  | 3.7%                | 9.1%                 |
| 37 - Building and Grounds Cleaning and Maintenance  | 2,441,462  | 1.3%                | 3.2%                 |
| 39 - Personal Care and Service                      | 3,691,927  | 2.0%                | 3.1%                 |
| 41 - Sales and Related                              | 22,709,208 | 12.0%               | 10.6%                |
| 43 - Office and Administrative Support              | 19,903,972 | 10.5%               | 16.1%                |
| 45 - Farming, Fishing, and Forestry                 | 126,592    | 0.1%                | 0.3%                 |
| 47 - Construction and Extraction                    | 1,998,832  | 1.1%                | 3.9%                 |
| 49 - Installation, Maintenance, and Repair          | 5,909,063  | 3.1%                | 3.9%                 |
| 51 - Production                                     | 4,897,885  | 2.6%                | 6.6%                 |
| 53 - Transportation and Material Moving             | 10,994,453 | 5.8%                | 6.9%                 |

## Low carbon job ads descriptive statistics

In this article, we use the common definition for high and low skilled occupations within the SOC classification: occupational major groups 11 to 29 are labeled high skilled, while major groups 31 to 53 are labeled low skilled.

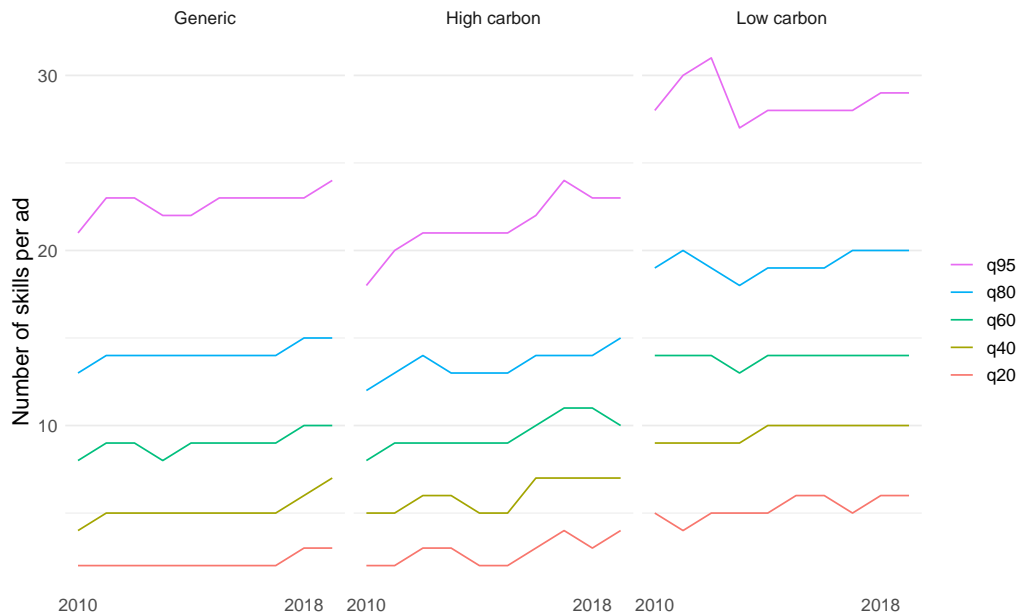


Figure SI.1: Distribution of the number of skills per job ad by category over time

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### High skilled occupations

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- 11 - Management Occupations
- 13 - Business and Financial Operations Occupations
- 15 - Computer and Mathematical Occupations
- 17 - Architecture and Engineering Occupations
- 19 - Life, Physical, and Social Science Occupations
- 21 - Community and Social Service Occupations
- 23 - Legal Occupations
- 25 - Educational Instruction and Library Occupations
- 27 - Arts, Design, Entertainment, Sports, and Media Occupations
- 29 - Healthcare Practitioners and Technical Occupations

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### Low skilled occupations

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- 31 - Healthcare Support Occupations
  - 33 - Protective Service Occupations
  - 35 - Food Preparation and Serving Related Occupations
  - 37 - Building and Grounds Cleaning and Maintenance Occupations
  - 39 - Personal Care and Service Occupations
  - 41 - Sales and Related Occupations
  - 43 - Office and Administrative Support Occupations
  - 45 - Farming, Fishing, and Forestry Occupations
  - 47 - Construction and Extraction Occupations
  - 49 - Installation, Maintenance, and Repair Occupations
  - 51 - Production Occupations
  - 53 - Transportation and Material Moving Occupations
-

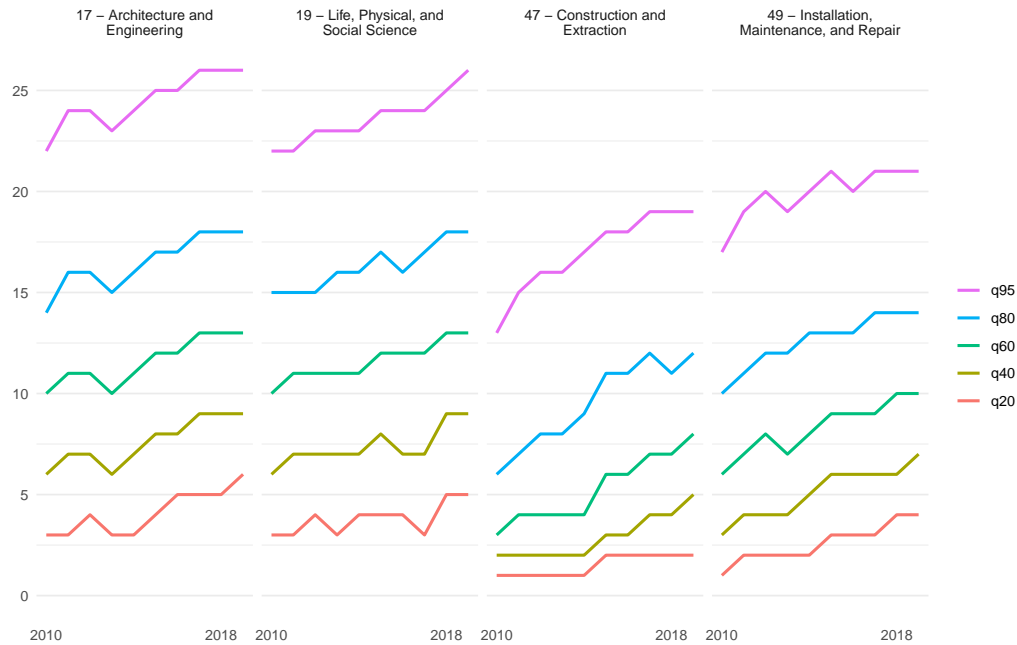


Figure SI.2: Distribution of the number of skills per job ad – Heterogeneity across occupations

Table SI.7: Share of low-carbon ads by SOC major group (2-digits), weighted by BLS employment

| SOC major group                                     | Low carbon ads | Share within occupation |
|---|----------------|-------------------------|
| 11 - Management                                     | 256,515        | 1.3%                    |
| 13 - Business and Financial Operations              | 95,727         | 1.7%                    |
| 15 - Computer and Mathematical                      | 121,578        | 0.6%                    |
| 17 - Architecture and Engineering                   | 233,436        | 4.1%                    |
| 19 - Life, Physical, and Social Science             | 50,355         | 3.6%                    |
| 21 - Community and Social Service                   | 5,083          | 0.3%                    |
| 23 - Legal  | 9,033          | 0.6%                    |
| 25 - Education, Training, and Library               | 31,610         | 0.6%                    |
| 27 - Arts, Design, Entertainment, Sports, and Media | 21,404         | 0.5%                    |
| 29 - Healthcare Practitioners and Technical         | 34,293         | 0.1%                    |
| 31 - Healthcare Support                             | 9,363          | 0.2%                    |
| 33 - Protective Service                             | 18,720         | 1.0%                    |
| 35 - Food Preparation and Serving Related           | 13,797         | 0.2%                    |
| 37 - Building and Grounds Cleaning and Maintenance  | 13,107         | 0.5%                    |
| 39 - Personal Care and Service                      | 12,284         | 0.3%                    |
| 41 - Sales and Related                              | 142,877        | 0.4%                    |
| 43 - Office and Administrative Support              | 90,492         | 0.4%                    |
| 45 - Farming, Fishing, and Forestry                 | 913            | 0.9%                    |
| 47 - Construction and Extraction                    | 94,725         | 4.1%                    |
| 49 - Installation, Maintenance, and Repair          | 170,476        | 2.6%                    |
| 51 - Production                                     | 46,594         | 0.9%                    |
| 53 - Transportation and Material Moving             | 201,263        | 7.4%                    |
| Total   | 1,673,645      | 1.4%                    |

Table SI.8 highlights the heterogeneity in the intensity of low-carbon ads within 2-digit SOC occupations. For instance, among the Business and Finance occupations (SOC 13), only Business Specialists (SOC 13-2) have a high share of low-carbon ads. Among Life, Physical and Social Science (SOC 19), all scientists are low-carbon intensive with respect to the global average, but Physical Scientists (SOC 19-2) stand out with a share of 8%. Among Architecture and Engineering (SOC 17), Architects (SOC 17-1), Engineers (SOC 17-2) and Technicians (SOC 17-3) have all an intensity of low-carbon ads well above 3%.

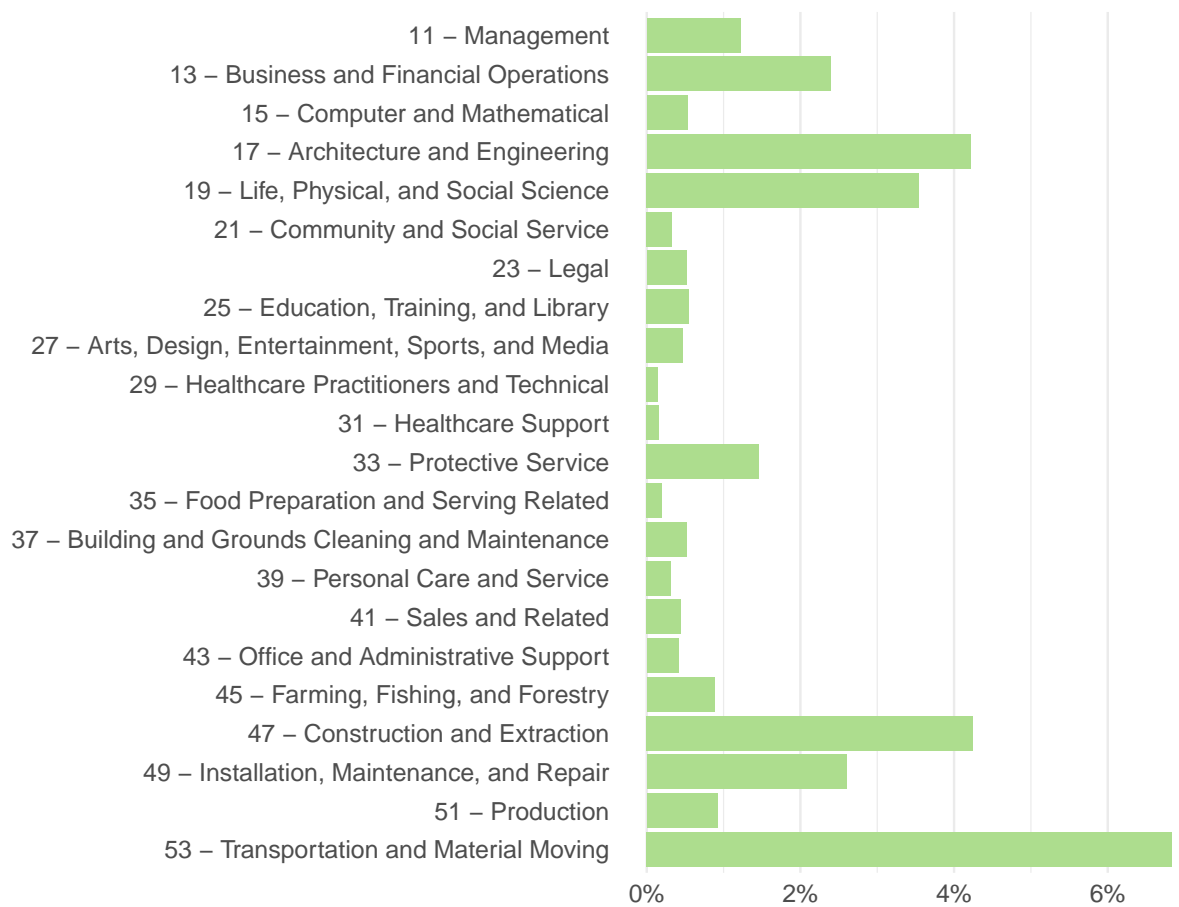


Figure SI.3: Low-carbon ads intensity by occupation (2010-2019)



Table SI.8: Share of low-carbon ads by SOC minor group (3-digits), weighted by BLS employment

| SOC minor group                                       | Low carbon ads | Share within occupation |
|---|----------------|-------------------------|
| 13-1 - Business Operations Specialists                | 78,545         | 2.5%                    |
| 13-2 - Financial Specialists                          | 17,182         | 0.4%                    |
| 17-1 - Architects, Surveyors, and Cartographers       | 10,473         | 4.3%                    |
| 17-2 - Engineers                                      | 180,294        | 4.3%                    |
| 17-3 - Engineering and Mapping Technicians            | 42,669         | 3.5%                    |
| 19-1 - Life Scientists                                | 10,379         | 2.3%                    |
| 19-2 - Physical Scientists                            | 20,064         | 8.0%                    |
| 19-3 - Social Scientists and Related Workers          | 8,588          | 2.3%                    |
| 19-4 - Life, Physical, and Social Science Technicians | 11,324         | 2.1%                    |
| Total   | 1,673,645      | 1.4%                    |

Table SI.9: Share of high-carbon ads by SOC minor group (3-digits), weighted by BLS employment

| SOC minor group   | High carbon ads | Share within occupation |
|---|-----------------|-------------------------|
| 17-2 - Engineers  | 99,572          | 4.1%                    |
| 47-1 - Supervisors of Construction and Extraction Workers | 3,658           | 3.2%                    |
| 47-2 - Construction Trades Workers                        | 12,356          | 0.8%                    |
| 47-3 - Helpers, Construction Trades                       | 82              | 0.2%                    |
| 47-4 - Other Construction and Related Workers             | 3,612           | 2.1%                    |
| 47-5 - Extraction Workers                                 | 90,530          | 100.0%                  |
| Total   | 209,810         | 0.3%                    |

Table SI.10: Share of low-carbon ads by year, weighted by BLS employment (2010-2019)

|   | 2010  | 2011  | 2012  | 2013  | 2014  | 2015  | 2016  | 2017  | 2018  | 2019  |
|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| <b>Overall</b>                                  |       |       |       |       |       |       |       |       |       |       |
| All   | 1.32% | 1.42% | 1.44% | 1.30% | 1.20% | 1.34% | 1.28% | 1.39% | 1.40% | 1.42% |
| <b>Overall - High skill</b>                     |       |       |       |       |       |       |       |       |       |       |
| All   | 0.36% | 0.41% | 0.37% | 0.30% | 0.30% | 0.32% | 0.29% | 0.29% | 0.30% | 0.30% |
| 13-1 - Business Operations Specialists          | 0.09% | 0.13% | 0.10% | 0.07% | 0.07% | 0.07% | 0.07% | 0.06% | 0.07% | 0.06% |
| 17-2 - Engineers                                | 0.06% | 0.07% | 0.05% | 0.05% | 0.05% | 0.05% | 0.05% | 0.05% | 0.05% | 0.05% |
| 17-3 - Engineering and Mapping Technicians      | 0.02% | 0.02% | 0.02% | 0.02% | 0.02% | 0.02% | 0.02% | 0.02% | 0.02% | 0.02% |
| Others  | 0.18% | 0.20% | 0.20% | 0.16% | 0.17% | 0.18% | 0.16% | 0.16% | 0.17% | 0.17% |
| <b>Overall - Low skill</b>                      |       |       |       |       |       |       |       |       |       |       |
| All   | 0.97% | 1.01% | 1.06% | 1.00% | 0.90% | 1.02% | 0.98% | 1.10% | 1.10% | 1.12% |
| 47 - Construction and Extraction                | 0.14% | 0.15% | 0.14% | 0.14% | 0.15% | 0.19% | 0.18% | 0.19% | 0.18% | 0.18% |
| 49 - Installation, Maintenance, and Repair      | 0.08% | 0.09% | 0.09% | 0.10% | 0.08% | 0.10% | 0.10% | 0.12% | 0.12% | 0.12% |
| 53 - Transportation and Material Moving         | 0.54% | 0.51% | 0.54% | 0.53% | 0.44% | 0.47% | 0.47% | 0.53% | 0.54% | 0.55% |
| Others  | 0.21% | 0.26% | 0.30% | 0.23% | 0.23% | 0.26% | 0.24% | 0.26% | 0.26% | 0.27% |
| <b>Within occupation group</b>                  |       |       |       |       |       |       |       |       |       |       |
| 13-1 - Business Operations Specialists          | 2.95% | 4.00% | 3.22% | 2.24% | 2.08% | 2.32% | 2.05% | 1.94% | 2.06% | 1.90% |
| 17-1 - Architects, Surveyors, and Cartographers | 3.30% | 4.15% | 3.20% | 2.84% | 5.81% | 7.31% | 4.75% | 3.42% | 3.99% | 4.20% |
| 17-2 - Engineers                                | 5.19% | 5.60% | 4.63% | 3.92% | 3.85% | 4.05% | 3.97% | 3.94% | 3.87% | 3.89% |
| 17-3 - Engineering and Mapping Technicians      | 3.68% | 4.11% | 3.30% | 3.09% | 3.53% | 3.34% | 3.43% | 3.65% | 3.45% | 3.61% |
| 19-2 - Physical Scientists                      | 8.15% | 8.95% | 8.12% | 7.73% | 7.86% | 8.75% | 7.14% | 7.33% | 8.52% | 7.85% |
| 47 - Construction and Extraction                | 3.52% | 3.72% | 3.62% | 3.45% | 3.70% | 4.77% | 4.62% | 4.96% | 4.48% | 4.56% |
| 49 - Installation, Maintenance, and Repair      | 2.01% | 2.42% | 2.24% | 2.64% | 2.18% | 2.61% | 2.50% | 3.04% | 3.05% | 3.09% |
| 53 - Transportation and Material Moving         | 7.78% | 7.44% | 7.80% | 7.65% | 6.43% | 6.88% | 6.78% | 7.73% | 7.83% | 8.00% |

*Notes:* Table SI.10 presents the annual share low-carbon ads for each of the SOC occupational groups harboring the most low-carbon positions. low-carbon shares are calculated at the SOC 6-digit level then weighted using mean employment by 6-digits occupation for the period 2010-2019 obtained from the BLS Occupational Employment and Wage Statistics.

Table SI.11: Share of low-carbon ads by NAICS sector (unweighted averages, 2010-2019)

| NAICS2  | Ad count   |            |             | Unweighted ad share |            |             |
|---|------------|------------|-------------|---------------------|------------|-------------|
|   | Generic    | Low carbon | High carbon | Generic             | Low carbon | High carbon |
| 11 - "Agriculture, Forestry, Fishing and Hunting"                             | 99,584     | 1,968      | 149         | 97.9%               | 1.9%       | 0.1%        |
| 21 - "Mining, Quarrying, and Oil and Gas Extraction"                          | 474,446    | 8,440      | 70,808      | 85.7%               | 1.5%       | 12.8%       |
| 22 - Utilities  | 483,609    | 69,603     | 6,593       | 86.4%               | 12.4%      | 1.2%        |
| 23 - Construction   | 1,598,110  | 64,288     | 3,931       | 95.9%               | 3.9%       | 0.2%        |
| 311 - Food Manufacturing  | 577,092    | 5,114      | 131         | 99.1%               | 0.9%       | 0.0%        |
| 312 - Beverage and Tobacco Product Manufacturing                              | 347,768    | 2,072      | 1,291       | 99.0%               | 0.6%       | 0.4%        |
| 313 - Textile Mills   | 691        | 8          | 0           | 98.9%               | 1.1%       | 0.0%        |
| 314 - Textile Product Mills   | 41,297     | 397        | 14          | 99.0%               | 1.0%       | 0.0%        |
| 315 - Apparel Manufacturing   | 79,365     | 103        | 2           | 99.9%               | 0.1%       | 0.0%        |
| 316 - Leather and Allied Product Manufacturing                                | 5,585      | 6          | 1           | 99.9%               | 0.1%       | 0.0%        |
| 321 - Wood Product Manufacturing  | 90,915     | 3,409      | 322         | 96.1%               | 3.6%       | 0.3%        |
| 322 - Paper Manufacturing   | 83,421     | 651        | 78          | 99.1%               | 0.8%       | 0.1%        |
| 323 - Printing and Related Support Activities                                 | 83,422     | 245        | 67          | 99.6%               | 0.3%       | 0.1%        |
| 324 - Petroleum and Coal Products Manufacturing                               | 112,773    | 5,033      | 21,616      | 80.9%               | 3.6%       | 15.5%       |
| 325 - Chemical Manufacturing  | 1,540,097  | 12,637     | 1,094       | 99.1%               | 0.8%       | 0.1%        |
| 326 - Plastics and Rubber Products Manufacturing                              | 74,002     | 698        | 6           | 99.1%               | 0.9%       | 0.0%        |
| 327 - Nonmetallic Mineral Product Manufacturing                               | 173,885    | 3,121      | 994         | 97.7%               | 1.8%       | 0.6%        |
| 331 - Primary Metal Manufacturing   | 121,384    | 1,632      | 784         | 98.0%               | 1.3%       | 0.6%        |
| 332 - Fabricated Metal Product Manufacturing                                  | 215,079    | 1,641      | 150         | 99.2%               | 0.8%       | 0.1%        |
| 333 - Machinery Manufacturing   | 761,968    | 13,694     | 489         | 98.2%               | 1.8%       | 0.1%        |
| 334 - Computer and Electronic Product Manufacturing                           | 1,568,119  | 19,823     | 756         | 98.7%               | 1.2%       | 0.0%        |
| 335 - "Electrical Equipment, Appliance, and Component Manufacturing"          | 127,518    | 4,277      | 69          | 96.7%               | 3.2%       | 0.1%        |
| 336 - Transportation Equipment Manufacturing                                  | 1,339,451  | 23,786     | 802         | 98.2%               | 1.7%       | 0.1%        |
| 337 - Furniture and Related Product Manufacturing                             | 76,814     | 2,787      | 84          | 96.4%               | 3.5%       | 0.1%        |
| 339 - Miscellaneous Manufacturing   | 388,605    | 1,416      | 48          | 99.6%               | 0.4%       | 0.0%        |
| 42 - Wholesale Trade  | 1,280,032  | 17,196     | 875         | 98.6%               | 1.3%       | 0.1%        |
| 441 - Motor Vehicle and Parts Dealers   | 1,295,983  | 9,693      | 29          | 99.3%               | 0.7%       | 0.0%        |
| 442 - Furniture and Home Furnishings Stores                                   | 324,729    | 434        | 62          | 99.8%               | 0.1%       | 0.0%        |
| 443 - Electronics and Appliance Stores  | 660,228    | 413        | 11          | 99.9%               | 0.1%       | 0.0%        |
| 444 - Building Material and Garden Equipment and Supplies Dealers             | 1,339,121  | 3,891      | 8           | 99.7%               | 0.3%       | 0.0%        |
| 445 - Food and Beverage Stores  | 1,580,339  | 2,752      | 156         | 99.8%               | 0.2%       | 0.0%        |
| 446 - Health and Personal Care Stores   | 1,370,651  | 5,786      | 32          | 99.6%               | 0.4%       | 0.0%        |
| 447 - Gasoline Stations   | 383,477    | 449        | 582         | 99.7%               | 0.1%       | 0.2%        |
| 448 - Clothing and Clothing Accessories Stores                                | 1,838,975  | 3,166      | 84          | 99.8%               | 0.2%       | 0.0%        |
| 451 - "Sporting Goods, Hobby, Book, and Music Stores"                         | 801,183    | 12,043     | 64          | 98.5%               | 1.5%       | 0.0%        |
| 452 - General Merchandise Stores  | 3,730,762  | 3,214      | 606         | 99.9%               | 0.1%       | 0.0%        |
| 453 - Miscellaneous Store Retailers   | 979,777    | 5,288      | 116         | 99.5%               | 0.5%       | 0.0%        |
| 454 - Nonstore Retailers  | 458,809    | 4,240      | 203         | 99.0%               | 0.9%       | 0.0%        |
| 481 - Air Transportation  | 273,811    | 1,381      | 44          | 99.5%               | 0.5%       | 0.0%        |
| 482 - Rail Transportation   | 66,015     | 11,662     | 418         | 84.5%               | 14.9%      | 0.5%        |
| 483 - Water Transportation  | 32,239     | 297        | 18          | 99.0%               | 0.9%       | 0.1%        |
| 484 - Truck Transportation  | 3,135,767  | 22,411     | 466         | 99.3%               | 0.7%       | 0.0%        |
| 485 - Transit and Ground Passenger Transportation                             | 107,803    | 64,296     | 28          | 62.6%               | 37.4%      | 0.0%        |
| 486 - Pipeline Transportation   | 50,036     | 2,426      | 7,733       | 83.1%               | 4.0%       | 12.8%       |
| 487 - Scenic and Sightseeing Transportation                                   | 948        | 29         | 0           | 97.0%               | 3.0%       | 0.0%        |
| 488 - Support Activities for Transportation                                   | 222,317    | 2,060      | 338         | 98.9%               | 0.9%       | 0.2%        |
| 491 - Postal Service  | 41,827     | 225        | 0           | 99.5%               | 0.5%       | 0.0%        |
| 492 - Couriers and Messengers   | 494,113    | 37,468     | 47          | 92.9%               | 7.0%       | 0.0%        |
| 493 - Warehousing and Storage   | 88,641     | 612        | 30          | 99.3%               | 0.7%       | 0.0%        |
| 51 - Information  | 5,124,341  | 27,940     | 9,484       | 99.3%               | 0.5%       | 0.2%        |
| 52 - Finance and Insurance  | 11,360,815 | 24,748     | 1,759       | 99.8%               | 0.2%       | 0.0%        |
| 53 - Real Estate and Rental and Leasing                                       | 2,650,165  | 24,766     | 580         | 99.1%               | 0.9%       | 0.0%        |
| 54 - "Professional, Scientific, and Technical Services"                       | 12,387,922 | 154,572    | 14,101      | 98.7%               | 1.2%       | 0.1%        |
| 55 - Management of Companies and Enterprises                                  | 221,745    | 2,066      | 98          | 99.0%               | 0.9%       | 0.0%        |
| 56 - Administrative and Support and Waste Management and Remediation Services | 7,359,522  | 70,788     | 3,822       | 99.0%               | 1.0%       | 0.1%        |
| 61 - Educational Services   | 8,312,462  | 91,904     | 620         | 98.9%               | 1.1%       | 0.0%        |
| 62 - Health Care and Social Assistance  | 21,620,327 | 42,922     | 5,645       | 99.8%               | 0.2%       | 0.0%        |
| 71 - "Arts, Entertainment, and Recreation"                                    | 1,141,376  | 8,114      | 245         | 99.3%               | 0.7%       | 0.0%        |
| 72 - Accommodation and Food Services  | 9,169,235  | 63,964     | 1,424       | 99.3%               | 0.7%       | 0.0%        |
| 81 - Other Services (except Public Administration)                            | 2,480,178  | 32,245     | 582         | 98.7%               | 1.3%       | 0.0%        |
| 92 - Public Administration  | 4,460,420  | 87,344     | 3,244       | 98.0%               | 1.9%       | 0.1%        |

Table SI.12: Evolution of the share of low-carbon ads, 2010-2012 vs 2017-2019

|                    | All                 | Low skilled         | High skilled         |
|--------------------|---------------------|---------------------|----------------------|
| 2017-19 vs 2010-12 | 0.000<br>(0.000)    | 0.001***<br>(0.000) | -0.001***<br>(0.000) |
| Constant           | 0.014***<br>(0.000) | 0.010***<br>(0.000) | 0.004***<br>(0.000)  |
| Observations       | 1.416               | 1.416               | 1.416                |
| $R^2$              | 0                   | 0.01                | 0.05                 |

*Notes:* We obtain the distribution of the share of low-carbon ads across commuting zones by year and low (high) skilled occupations. Table SI.12 regresses this low-carbon share on a dummy indicator for the period 2017-2019, contrasting with the 2010-2012 baseline for (1) All occupations; (2) Low skilled occupations and (3) High skilled occupations. Thus, a coefficient of 0.001 in column (2) indicates that the share of low-carbon ads in low-skilled occupations was 0.1% higher in 2017-2019 than in 2010-2012.

Table SI.13: Evolution of in selected SOC groups, 2010-2012 vs 2017-2019

|                    | 13-1                 | 17-1                | 17-2                 | 17-3                | 19-2                | 47                  | 49                  | 53                  |
|--------------------|----------------------|---------------------|----------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| 2017-19 vs 2010-12 | -0.015***<br>(0.001) | -0.008**<br>(0.004) | -0.013***<br>(0.002) | -0.003<br>(0.003)   | -0.008<br>(0.005)   | 0.008***<br>(0.002) | 0.007***<br>(0.001) | -0.001<br>(0.003)   |
| Constant           | 0.035***<br>(0.002)  | 0.054***<br>(0.004) | 0.053***<br>(0.002)  | 0.040***<br>(0.002) | 0.096***<br>(0.007) | 0.040***<br>(0.002) | 0.023***<br>(0.001) | 0.079***<br>(0.003) |
| Observations       | 845                  | 338                 | 1.062                | 889                 | 639                 | 1.082               | 1.197               | 1.267               |
| $R^2$              | 0.13                 | 0.01                | 0.08                 | 0                   | 0                   | 0.03                | 0.06                | 0                   |

*Notes:* Table SI.13 applies the same approach as Table SI.12 in each of the SOC groups we focus on in the present article. For reference: 13-1 - Business Operations Specialists; 17-1 - Architects, Surveyors, and Cartographers; 17-2 - Engineers; 17-3 - Engineering and Mapping Technicians; 19-2 - Physical Scientists; 47 - Construction and Extraction; 49 - Installation, Maintenance, and Repair; 53 - Transportation and Material Moving.

## Spatial correlation between low and high-carbon vacancies and income levels

Table SI.14: Correlation between the share of low-carbon ads and annual personal income

|                  | Low skill           |                      |                        |
|------------------|---------------------|----------------------|------------------------|
|                  | Unweighted          | Weighted by ad count | Weighted by population |
| $\log(inc_{cz})$ | 0.006***<br>(0.001) | 0.002*<br>(0.001)    | 0.002**<br>(0.001)     |
| Observations     | 685                 | 685                  | 685                    |
| R2               | 0.03                | 0.01                 | 0.02                   |
| AIC              | -4.974              | -4.960               | -4.961                 |

Notes: Table SI.14 presents estimates of  $\beta_{lc}^{inc}$  in  $\log(1 + s_{lc,cz}) = \beta_{lc}^{inc} \log(inc_{cz}) + \varepsilon_{cz}$ .  $s_{lc,cz}$  is the average share of low-carbon ads in low skilled occupations between 2010 and 2019 in each CZ.  $inc_{cz}$  is the mean income per capita between 2010 and 2019 in each CZ. Column (1) presents unweighted results, while column (2) provides results weighted by the average number of job ads between 2010 and 2019 in each CZ and column (3) weighted by the average population per CZ between 2010 and 2019. Standard errors clustered by CZ are provided in parentheses.

Table SI.15: Correlation between the share of high-carbon ads and annual personal income

|                  | Low skill           |                      |                        |
|------------------|---------------------|----------------------|------------------------|
|                  | Unweighted          | Weighted by ad count | Weighted by population |
| $\log(inc_{cz})$ | 0.007***<br>(0.002) | -0.001**<br>(0.000)  | -0.001***<br>(0.000)   |
| Observations     | 647                 | 647                  | 647                    |
| R2               | 0.03                | 0.01                 | 0.01                   |
| AIC              | -4.522              | -4.456               | -4.459                 |

Notes: Table SI.15 presents estimates of  $\beta_{hc}^{inc}$  in  $\log(1 + s_{hc,cz}) = \beta_{hc}^{inc} \log(inc_{cz}) + \varepsilon_{cz}$ .  $s_{hc,cz}$  is the average share of high-carbon ads in low skilled occupations between 2010 and 2019 in each CZ.  $inc_{cz}$  is

the mean income per capita between 2010 and 2019 in each CZ. Column (1) presents unweighted results, while column (2) provides results weighted by the average number of job ads between 2010 and 2019 in each CZ and column (3) weighted by the average population per CZ between 2010 and 2019. Standard errors clustered by CZ are provided in parentheses.

Table SI.16: Correlation between the share of low and high-carbon ads

|                       | Low skill          |                      |                        |
|-----------------------|--------------------|----------------------|------------------------|
|                       | Unweighted         | Weighted by ad count | Weighted by population |
| $\log(1 + s_{hc,cz})$ | 0.122**<br>(0.057) | 0.065<br>(0.045)     | 0.067<br>(0.052)       |
| Observations          | 650                | 650                  | 646                    |
| R2                    | 0.02               | 0.00                 | 0.00                   |
| AIC                   | -4.760             | -4.757               | -4.728                 |

*Notes:* Table SI.16 presents estimates of  $\beta_{lc,hc}$  in  $\log(1 + s_{lc,cz}) = \beta_{lc,hc} \log(1 + s_{hc,cz}) + \varepsilon_{cz}$ .  $s_{lc,cz}$  is the average share of low-carbon ads in low skilled occupations between 2010 and 2019 in each CZ.  $s_{hc,cz}$  is the average share of high-carbon ads in low skilled occupations between 2010 and 2019 in each CZ. Column (1) presents unweighted results, while column (2) provides results weighted by the average number of job ads between 2010 and 2019 in each CZ and column (3) weighted by the average population per CZ between 2010 and 2019. Standard errors clustered by CZ are provided in parentheses.

Table SI.17: Correlation between the share of low-carbon ads and high-carbon employment

|                             | Low skill           |                      |                        |
|-----------------------------|---------------------|----------------------|------------------------|
|                             | Unweighted          | Weighted by ad count | Weighted by population |
| $\log(1 + s_{hc,cz}^{emp})$ | 0.096***<br>(0.028) | 0.020<br>(0.020)     | 0.017<br>(0.022)       |
| Observations                | 687                 | 687                  | 685                    |
| R2                          | 0.03                | 0.00                 | 0.00                   |
| AIC                         | -5.011              | -4.996               | -4.981                 |

*Notes:* Table SI.17 presents estimates of  $\beta_{lc,hc}^{emp}$  in  $\log(1 + s_{lc,cz}) = \beta_{lc,hc}^{emp} \log(1 + s_{hc,cz}^{emp}) + \varepsilon_{cz}$ .  $s_{lc,cz}$  is the average share of low-carbon ads in low skilled occupations between 2010 and 2019 in each CZ.  $s_{hc,cz}^{emp}$  is the average share of high-carbon employment in low skilled occupations between 2010 and 2017 in each CZ, according to the American Community Survey (ACS). Column (1) presents unweighted results, while column (2) provides results weighted by the average number of job ads between 2010 and 2019 in each CZ and column (3) weighted by the average population per CZ between 2010 and 2019. Standard errors clustered by CZ are provided in parentheses.

Table SI.18: Locational Gini

|           | Low carbon ads | High carbon employment | High carbon ads | Generic ads                       |
|-----------|----------------|------------------------|-----------------|-----------------------------------|
| Low skill | 0.33           | 0.98                   | 0.69            | Construction & Extraction<br>0.23 |

*Notes:* Table SI.18 presents the Locational Gini for share of low-carbon ads per CZ, share of high-carbon employment per CZ, share of high-carbon ads per CZ and share of Construction & Extraction ads (SOC 47) per CZ. The Gini locational coefficient is calculated following [24] using our own job ads dataset and data on employment by occupation and commuting zone from the American Community Survey adapted from [39]. For any of variables presented in the four columns listed above, indexed by  $k$ , it can be expressed as:

$$LocGini_k = \Delta/4u$$

- where
- $\Delta = \{1/[n(n-1)]\} \sum_{i=1}^n \sum_{j=1}^n |x_i - x_j|$
  - $i, j =$  US commuting zones ( $i \neq j$ )
  - $n =$  Total number of CZ under ERS 2000 (709)
  - $u =$  mean of the share variable  $k$  across all CZ
  - $x_{i(j)} =$ 

|   |   |   |
|---|---|---|
| (1) [CZ $i$ 's ( $j$ 's) share of low-carbon ads]   | / | [CZ $i$ 's ( $j$ 's) share of all ads]  |
| (2) [CZ $i$ 's ( $j$ 's) share of high-carbon emp.] | / | [CZ $i$ 's ( $j$ 's) share of all emp.] |
| (3) [CZ $i$ 's ( $j$ 's) share of high-carbon ads]  | / | [CZ $i$ 's ( $j$ 's) share of all ads]  |
| (4) [CZ $i$ 's ( $j$ 's) share of SOC 47 ads]       | / | [CZ $i$ 's ( $j$ 's) share of all ads]  |

Table SI.19: Top low-carbon job identifiers by state

| State          | Most freq. low carbon    | 2 <sup>nd</sup> most freq. | 3 <sup>rd</sup> most freq.   |
|----------------|--------------------------|----------------------------|------------------------------|
| Alabama        | Insulation               | Bus Driving                | Energy Conservation          |
| Alaska         | Insulation               | Bus Driving                | Pollution Control            |
| Arizona        | Bus Driving              | Insulation                 | Renewable Energy             |
| Arkansas       | Insulation               | Bus Driving                | Energy Efficiency            |
| California     | Energy Efficiency        | Renewable Energy           | Bus Driving                  |
| Colorado       | Renewable Energy         | Energy Efficiency          | Insulation                   |
| Connecticut    | Energy Efficiency        | Bus Driving                | Insulation                   |
| Delaware       | Bus Driving              | Insulation                 | Energy Efficiency            |
| Florida        | Insulation               | Energy Conservation        | Bus Driving                  |
| Georgia        | Insulation               | Energy Conservation        | Bus Driving                  |
| Hawaii         | Bus Driving              | Energy Conservation        | Renewable Energy             |
| Idaho          | Clean Energy             | Bus Driving                | Insulation                   |
| Illinois       | Bus Driving              | Energy Efficiency          | Insulation                   |
| Indiana        | Insulation               | Bus Driving                | Energy Efficiency            |
| Iowa           | Ethanol                  | Insulation                 | Bus Driving                  |
| Kansas         | Bus Driving              | Insulation                 | Environmental Sustainability |
| Kentucky       | Insulation               | Bus Driving                | Solar Panels                 |
| Louisiana      | Insulation               | Energy Efficiency          | Energy Conservation          |
| Maine          | Bus Driving              | Insulation                 | Renewable Energy             |
| Maryland       | Insulation               | Energy Efficiency          | Bus Driving                  |
| Massachusetts  | Energy Efficiency        | Renewable Energy           | Energy Conservation          |
| Michigan       | Bus Driving              | Fuel Efficiency            | Insulation                   |
| Minnesota      | Bus Driving              | Insulation                 | Energy Conservation          |
| Mississippi    | Insulation               | Energy Efficiency          | Bus Driving                  |
| Missouri       | Bus Driving              | Insulation                 | Energy Conservation          |
| Montana        | Bus Driving              | Insulation                 | Energy Conservation          |
| Nebraska       | Insulation               | Ethanol                    | Bus Driving                  |
| Nevada         | Bus Driving              | Energy Conservation        | Insulation                   |
| New Hampshire  | Bus Driving              | Insulation                 | Energy Efficiency            |
| New Jersey     | Bus Driving              | Energy Efficiency          | Insulation                   |
| New Mexico     | Bus Driving              | Insulation                 | Renewable Energy             |
| New York       | Energy Efficiency        | Renewable Energy           | Bus Driving                  |
| North Carolina | Insulation               | Bus Driving                | Energy Efficiency            |
| North Dakota   | Insulation               | Wind Power                 | Wind Turbines                |
| Ohio           | Insulation               | Bus Driving                | Energy Efficiency            |
| Oklahoma       | Insulation               | Bus Driving                | Energy Efficiency            |
| Oregon         | Energy Efficiency        | Bus Driving                | Insulation                   |
| Pennsylvania   | Bus Driving              | Insulation                 | Energy Efficiency            |
| Rhode Island   | Bus Driving              | Insulation                 | Energy Efficiency            |
| South Carolina | Insulation               | Bus Driving                | Energy Conservation          |
| South Dakota   | Ethanol                  | Bus Driving                | Insulation                   |
| Tennessee      | Insulation               | Energy Conservation        | Energy Efficiency            |
| Texas          | Insulation               | Bus Driving                | Energy Efficiency            |
| Utah           | Energy Conservation      | Insulation                 | Bus Driving                  |
| Vermont        | Bus Driving              | Energy Efficiency          | Insulation                   |
| Virginia       | Insulation               | Energy Efficiency          | Bus Driving                  |
| Washington     | Insulation               | Energy Efficiency          | Bus Driving                  |
| West Virginia  | Insulation               | Bus Driving                | Clean Air Act                |
| Wisconsin      | Bus Driving              | Insulation                 | Energy Efficiency            |
| Wyoming        | Efficient Transportation | Insulation                 | Bus Driving                  |



## Skill gap

Table SI.20: Skill gap

|  | Cognitive |       | IT    |       | Management |       | Social |       | Technical |       |
|--|-----------|-------|-------|-------|------------|-------|--------|-------|-----------|-------|
|  | 1         | 2+    | 1     | 2+    | 1          | 2+    | 1      | 2+    | 1         | 2+    |
| <b>13-1 - Business Operations Specialists</b>          |           |       |       |       |            |       |        |       |           |       |
| Generic  | 25.2%     | 9.9%  | 21.1% | 28.7% | 26.0%      | 22.4% | 28.0%  | 28.2% | 16.2%     | 2.1%  |
| Low carbon   | 26.3%     | 10.9% | 20.7% | 27.4% | 26.3%      | 28.7% | 27.9%  | 33.7% | 21.2%     | 8.8%  |
| <b>17-1 - Architects, Surveyors, and Cartographers</b> |           |       |       |       |            |       |        |       |           |       |
| Generic  | 18.1%     | 3.9%  | 15.9% | 24.3% | 24.9%      | 14.9% | 25.6%  | 18.5% | 16.9%     | 7.3%  |
| Low carbon   | 22.7%     | 10.5% | 28.1% | 16.1% | 31.4%      | 26.5% | 28.6%  | 32.4% | 27.3%     | 16.0% |
| <b>17-2 - Engineers</b>                                |           |       |       |       |            |       |        |       |           |       |
| Generic  | 25.2%     | 7.2%  | 19.7% | 26.8% | 24.3%      | 13.8% | 26.0%  | 20.0% | 25.6%     | 20.1% |
| High carbon  | 23.7%     | 5.5%  | 21.3% | 15.9% | 28.1%      | 13.8% | 29.0%  | 19.6% | 26.7%     | 22.3% |
| Low carbon   | 26.9%     | 7.8%  | 22.7% | 25.0% | 29.9%      | 21.4% | 31.0%  | 25.0% | 29.7%     | 28.3% |
| <b>17-3 - Engineering and Mapping Technicians</b>      |           |       |       |       |            |       |        |       |           |       |
| Generic  | 16.6%     | 3.1%  | 15.4% | 16.4% | 13.7%      | 5.4%  | 20.3%  | 11.7% | 19.5%     | 9.0%  |
| Low carbon   | 20.6%     | 4.5%  | 18.7% | 21.1% | 23.9%      | 11.9% | 28.9%  | 18.9% | 28.2%     | 16.2% |
| <b>19-2 - Physical Scientists</b>                      |           |       |       |       |            |       |        |       |           |       |
| Generic  | 33.5%     | 16.9% | 15.6% | 11.5% | 19.9%      | 10.1% | 25.0%  | 21.1% | 15.4%     | 3.3%  |
| Low carbon   | 35.9%     | 12.6% | 17.9% | 19.0% | 26.1%      | 29.8% | 27.0%  | 27.3% | 22.1%     | 7.6%  |
| <b>47 - Construction and Extraction</b>                |           |       |       |       |            |       |        |       |           |       |
| Generic  | 6.3%      | 1.2%  | 5.2%  | 2.5%  | 8.2%       | 3.0%  | 11.4%  | 4.2%  | 12.3%     | 3.1%  |
| High carbon  | 14.3%     | 1.6%  | 10.9% | 12.2% | 10.7%      | 4.4%  | 19.7%  | 8.6%  | 14.1%     | 3.1%  |
| Low carbon   | 9.9%      | 1.6%  | 10.9% | 3.9%  | 14.6%      | 5.0%  | 15.0%  | 11.8% | 13.6%     | 5.2%  |
| <b>49 - Installation, Maintenance, and Repair</b>      |           |       |       |       |            |       |        |       |           |       |
| Generic  | 12.3%     | 1.8%  | 9.1%  | 7.3%  | 13.0%      | 6.5%  | 20.5%  | 9.5%  | 13.2%     | 3.3%  |
| Low carbon   | 11.6%     | 2.3%  | 12.2% | 8.6%  | 24.4%      | 8.3%  | 28.6%  | 14.4% | 24.6%     | 5.4%  |
| <b>53 - Transportation and Material Moving</b>         |           |       |       |       |            |       |        |       |           |       |
| Generic  | 5.2%      | 0.4%  | 2.8%  | 1.1%  | 4.7%       | 1.4%  | 7.5%   | 2.7%  | 1.7%      | 0.1%  |
| Low carbon   | 5.1%      | 0.5%  | 2.7%  | 1.2%  | 4.9%       | 1.5%  | 14.4%  | 5.2%  | 4.6%      | 0.2%  |

*Notes:* Within each occupation and ad category (generic or low-carbon), the value listed reports the unweighted sample share of ads containing exactly one, or 2 or more skills in each of the five broad skill categories. E.g. 25.2% of generic Business and Operations Specialists ads require exactly one Cognitive skill.

Table SI.21: Skill gap magnitude across commuting zones

(a) Extensive margin

| SOC group                                       | Cognitive  | IT         | Management | Social     | Technical  |
|---|------------|------------|------------|------------|------------|
| <b>a) Low carbon vs Generic ads</b>             |            |            |            |            |            |
| 13-1 - Business Operations Specialists          | 1.30% *    | -0.30%     | 0.50%      | -0.10%     | 5.10% ***  |
| 17-1 - Architects, Surveyors, and Cartographers | 5.50% ***  | 13.90% *** | 7.10% ***  | 4.10% ***  | 11.20% *** |
| 17-2 - Engineers                                | 1.70% ***  | 3.10% ***  | 5.50% ***  | 5.00% ***  | 4.20% ***  |
| 17-3 - Engineering and Mapping Technicians      | 4.40% ***  | 3.80% ***  | 10.80% *** | 8.90% ***  | 9.10% ***  |
| 19-2 - Physical Scientists                      | 2.80% ***  | 2.70% ***  | 6.80% ***  | 2.50% ***  | 7.20% ***  |
| 47 - Construction and Extraction                | 4.00% ***  | 6.10% ***  | 6.70% ***  | 3.90% ***  | 1.40% ***  |
| 49 - Installation, Maintenance, and Repair      | -0.60% *   | 3.20% ***  | 11.60% *** | 8.20% ***  | 11.70% *** |
| 53 - Transportation and Material Moving         | 0.20%      | 0.10%      | 0.40%      | 7.10% ***  | 3.10% ***  |
| <b>b) High carbon vs Generic ads</b>            |            |            |            |            |            |
| 17-2 - Engineers                                | -1.40% *   | 1.70% ***  | 3.90% ***  | 3.20% ***  | 1.30% *    |
| 47 - Construction and Extraction                | 8.30% ***  | 6.00% ***  | 2.80% ***  | 8.50% ***  | 2.00% ***  |
| <b>c) Low carbon vs High carbon ads</b>         |            |            |            |            |            |
| 17-2 - Engineers                                | 3.10% ***  | 1.30% **   | 1.60% **   | 1.80% **   | 2.90% ***  |
| 47 - Construction and Extraction                | -4.40% *** | 0.10%      | 4.00% ***  | -4.70% *** | -0.60%     |

(b) Intensive margin

| SOC group                                       | Cognitive  | IT          | Management | Social     | Technical  |
|---|------------|-------------|------------|------------|------------|
| <b>a) Low carbon vs Generic ads</b>             |            |             |            |            |            |
| 13-1 - Business Operations Specialists          | 1.30% **   | -1.20% *    | 6.50% ***  | 5.70% ***  | 6.90% ***  |
| 17-1 - Architects, Surveyors, and Cartographers | 8.00% ***  | -7.10% ***  | 12.50% *** | 14.70% *** | 10.30% *** |
| 17-2 - Engineers                                | 0.80% **   | -1.70% *    | 7.60% ***  | 5.20% ***  | 8.30% ***  |
| 17-3 - Engineering and Mapping Technicians      | 2.20% ***  | 5.30% ***   | 7.10% ***  | 8.10% ***  | 8.00% ***  |
| 19-2 - Physical Scientists                      | -3.50% *** | 8.20% ***   | 20.10% *** | 6.90% ***  | 4.90% ***  |
| 47 - Construction and Extraction                | 0.70% ***  | 1.70% ***   | 2.30% ***  | 8.20% ***  | 2.40% ***  |
| 49 - Installation, Maintenance, and Repair      | 0.60% ***  | 1.40% ***   | 1.90% ***  | 5.10% ***  | 2.30% ***  |
| 53 - Transportation and Material Moving         | 0.20% **   | 0.30% **    | 0.30% **   | 2.80% ***  | 0.30% ***  |
| <b>b) High carbon vs Generic ads</b>            |            |             |            |            |            |
| 17-2 - Engineers                                | -1.40% *** | -10.70% *** | 0.20%      | -0.10%     | 2.60% **   |
| 47 - Construction and Extraction                | 0.80% ***  | 10.00% ***  | 1.60% ***  | 4.80% ***  | 0.20%      |
| <b>c) Low carbon vs High carbon ads</b>         |            |             |            |            |            |
| 17-2 - Engineers                                | 2.20% ***  | 9.00% ***   | 7.40% ***  | 5.30% ***  | 5.70% ***  |
| 47 - Construction and Extraction                | 0.00%      | -8.30% ***  | 0.80% **   | 3.50% ***  | 2.20% ***  |

*Notes:* Similarly to Table SI.20, we compute for each occupation and ad category (generic, low- or high-carbon), the unweighted share of ads containing exactly one (extensive margin), or 2 or more skills (intensive margin) in each of the five broad skill categories. We repeat this calculation in each commuting zone as defined in section . We then use the resulting distribution to test the statistical significance of the skill gap magnitude between each ad category pair. Panel a) reports the difference between low-carbon and generic ads in each occupation. A positive (resp. negative) value indicates that low-carbon ads

require the particular broad skill considered more (resp. less) frequently. *E.g.* the share of low-carbon Engineers ads requiring exactly one technical skill is 4.2% higher than their generic counterparts, while the share requiring two or more technical skills is 8.3% higher. Stars indicate the statistical significance of this difference, with three stars corresponding to the 1% threshold. Similarly, Panel b) compares the skill intensity of high-carbon and generic ads (a positive value indicates that high-carbon ads require more of the skill considered), and Panel c) compares the skill intensity of low and high-carbon ads (a positive value indicates that low carbon ads require more of the skill considered).

Table SI.22: Difference in skill gap between 2010-2012 and 2017-2019, across commuting zones

(a) Extensive margin

| SOC group                                       | Cognitive  | IT         | Management | Social     | Technical  |
|---|------------|------------|------------|------------|------------|
| <b>a) Low carbon vs Generic ads</b>             |            |            |            |            |            |
| 13-1 - Business Operations Specialists          | 2.10% **   | 3.30% ***  | 1.40%      | 1.80% **   | 0.00%      |
| 17-1 - Architects, Surveyors, and Cartographers | -2.70%     | 2.30%      | -0.50%     | -3.10%     | 2.80%      |
| 17-2 - Engineers                                | -1.90% *** | 0.10%      | -1.50% **  | 3.40% ***  | 3.20% ***  |
| 17-3 - Engineering and Mapping Technicians      | 0.40%      | 1.70% *    | 1.30%      | 2.70% **   | 5.90% ***  |
| 19-2 - Physical Scientists                      | -0.80%     | 0.70%      | -2.00%     | -2.90% *   | 1.60%      |
| 47 - Construction and Extraction                | 2.00% ***  | -2.00% *** | -5.80% *** | -1.50% *   | -1.60% **  |
| 49 - Installation, Maintenance, and Repair      | -2.30% *** | -0.80% *   | -6.80% *** | -3.10% *** | -5.10% *** |
| 53 - Transportation and Material Moving         | -1.10% **  | 0.80% ***  | -0.40%     | 6.10% ***  | 0.30%      |
| <b>b) High carbon vs Generic ads</b>            |            |            |            |            |            |
| 17-2 - Engineers                                | -1.20%     | -2.10% *   | -2.20%     | -2.00% *   | -2.00% *   |
| 47 - Construction and Extraction                | -1.30% **  | -2.40% *** | -4.20% *** | -1.80% *** | -3.40% *** |
| <b>c) Low carbon vs High carbon ads</b>         |            |            |            |            |            |
| 17-2 - Engineers                                | -0.70%     | 2.20% *    | 0.70%      | 5.40% ***  | 5.20% ***  |
| 47 - Construction and Extraction                | 3.20% ***  | 0.40%      | -1.50%     | 0.30%      | 1.80% **   |

(b) Intensive margin

| SOC group                                       | Cognitive  | IT         | Management | Social     | Technical  |
|---|------------|------------|------------|------------|------------|
| <b>a) Low carbon vs Generic ads</b>             |            |            |            |            |            |
| 13-1 - Business Operations Specialists          | 1.10% **   | 5.20% ***  | 2.40% ***  | 7.40% ***  | 0.80%      |
| 17-1 - Architects, Surveyors, and Cartographers | 9.80% ***  | 0.20%      | 0.50%      | 3.80% *    | 0.80%      |
| 17-2 - Engineers                                | -0.40%     | -3.70% *** | 0.50%      | 2.20% ***  | 2.70% ***  |
| 17-3 - Engineering and Mapping Technicians      | -1.20% **  | -0.10%     | -1.50%     | 1.80%      | -1.60%     |
| 19-2 - Physical Scientists                      | 2.30% **   | -1.90%     | 4.40% ***  | 1.40%      | 0.80%      |
| 47 - Construction and Extraction                | -0.70% *** | -0.90% **  | -2.80% *** | 0.10%      | -1.30% **  |
| 49 - Installation, Maintenance, and Repair      | -3.50% *** | -2.50% *** | -0.90% *** | 9.70% ***  | -3.40% *** |
| 53 - Transportation and Material Moving         | 0.10%      | -0.70% *** | -1.00% *** | 2.80% ***  | -0.40% *** |
| <b>b) High carbon vs Generic ads</b>            |            |            |            |            |            |
| 17-2 - Engineers                                | 0.90%      | -0.10%     | 6.20% ***  | 0.00%      | 0.10%      |
| 47 - Construction and Extraction                | -1.00% *** | 6.90% ***  | -0.90%     | -3.30% *** | -0.70% **  |
| <b>c) Low carbon vs High carbon ads</b>         |            |            |            |            |            |
| 17-2 - Engineers                                | -1.40%     | -3.60% **  | -5.70% *** | 2.20%      | 2.60% *    |
| 47 - Construction and Extraction                | 0.20%      | -7.80% *** | -1.90% **  | 3.50% ***  | -0.60%     |

*Notes:* We now turn to the evolution of the skill gap between job categories over time. We implement the approach described in Table SI.21 to compute the distribution of the skill gap between pairs of job categories across CZs in the periods 2010-12 and 2017-19. We then compare its evolution by regressing the skill gap over an indicator variable valued at 0 for the years 2010-12 and 1 over 2017-19. Thus a positive (resp. negative) value indicates a reduction (resp. increase) in the skill gap over time.

## Low and high-carbon skill coreness index

To analyse whether the skill requirements of low-carbon jobs represent a specialisation or diversification of skills sets, we analyse the correlation between two indices : a generic skill coreness index  $G_s^{SOC}$  and a low (resp. high) carbon skill coreness index  $C_s^{SOC}$ . These indices are defined within each SOC occupational groups (at the 2- or 3-digit level) as follows:

$$G_s^{SOC} = \frac{g_s^{SOC} - 1}{g_s^{SOC} + 1}$$

$$g_s^{SOC} = \frac{n_s^{SOC}}{n^{SOC}} / \frac{n_s}{n}$$

$$C_s^{SOC} = \frac{c_s^{SOC} - 1}{c_s^{SOC} + 1}$$

$$c_s^{SOC} = \frac{n_s^{c,SOC}}{n^{c,SOC}} / \frac{n_s^{SOC}}{n^{SOC}}$$

where  $n_s^{SOC}$  is the number of ads requiring skill  $s$  in occupational group  $SOC$

$n^{SOC}$  is the number of ads in occupational group  $SOC$

$n_s$  is the number of ads requiring skill  $s$  in the entire sample

$n$  is the total number of ads in the sample

$n_s^{c,SOC}$  is the number of low (resp. high) carbon ads requiring skill  $s$  in occupational group  $SOC$

$n^{c,SOC}$  is the number of low (resp. high) carbon ads in occupational group  $SOC$

$n_s^{SOC}$  is the number of ads requiring skill  $s$  in occupational group  $SOC$

$n^{SOC}$  is the number of ads in occupational group  $SOC$

The generic skill coreness index  $g_s^{SOC}$  compares skill  $s$ 's importance or coreness in SOC  $j$  to its coreness across all occupations. A value of  $g_s^{SOC}$  above 1 indicates that skill  $s$ 's coreness in SOC  $j$  is greater than its coreness across all occupations, indicating it is more in demand by SOC. The low- (or high-) carbon skill coreness index  $c_s^{SOC}$  compares skill  $s$ 's coreness in low- (or high-) carbon jobs in SOC  $j$  to its coreness in SOC  $j$  overall including generic jobs. A value of  $c_s^{SOC}$  above 1 indicates that skill  $s$ 's coreness in low-(or high-) carbon jobs in SOC  $j$  is greater than its coreness across all jobs in SOC  $j$ , indicating it is more in demand by low- (or high-)

carbon jobs within SOC  $j$ .

The distribution of  $G_s^{SOC}$  and  $C_s^{SOC}$  symmetrically ranges from -1 to +1 with 0 being the neutral point.

If and only if:

$$corr(G_s^{SOC}, C_s^{SOC}) > 0$$

then the skills required for low-carbon jobs in occupation  $j$  belong to the core set of skill sets demanded by that occupation, thus indicating that a transition to low-carbon jobs will require workers to expand their skill profile by further specialisation in their area of work.

Conversely, if and only if:

$$corr(G_s^{SOC}, C_s^{SOC}) < 0$$

then the increase in skill requirements of low-carbon jobs in occupation  $j$  instead demands workers to diversify their skill-sets and acquire new skills that don't belong to the usual skill profile of their occupation.

Table SI.23: Keywords defining broad skills

| Broad skill | Keywords  |
|-------------|---|
| Cognitive   | problem solving, research, analytical, critical thinking, math, statistics  |
| IT          | <i>Burning Glass Technologies Information Technology skill cluster family</i>   |
| Management  | project management, system analysis, system evaluat*, updat* kno*, using know*, consultation* advice*, supervisory, leadership, management, mentoring, staff                                |
| Social      | communication, teamwork, collaboration, negotiation, presentation   |
| Technical   | engineer*, technolog*, design, build*, construct*, mechanic*, draft, lay* out, specfiy* techn* part*, specfiy* techn* devic*, specify*, techn* equip*, estimat* quant* character*, technic* |

# Wage regressions robustness

Table SI.24: Wage gap robustness

|  | Main specification   |                     |                      |                     | Control for degree   |                      |                      |                     | Control for industry |                      |                     |                     |
|--|----------------------|---------------------|----------------------|---------------------|----------------------|----------------------|----------------------|---------------------|----------------------|----------------------|---------------------|---------------------|
|  | Weighted             |                     | Unweighted           |                     | Weighted             |                      | Unweighted           |                     | Weighted             |                      | Unweighted          |                     |
|  | 2010-2012            | 2017-2019           | 2010-2012            | 2017-2019           | 2010-2012            | 2017-2019            | 2010-2012            | 2017-2019           | 2010-2012            | 2017-2019            | 2010-2012           | 2017-2019           |
| <b>13-1 - Business Operations Specialists</b>          |                      |                     |                      |                     |                      |                      |                      |                     |                      |                      |                     |                     |
| Job ad is low carbon                                   | 0.062***<br>(0.017)  | 0.044*<br>(0.022)   | 0.063***<br>(0.019)  | 0.034<br>(0.020)    | 0.027<br>(0.026)     | 0.047**<br>(0.017)   | 0.026<br>(0.023)     | 0.042**<br>(0.015)  | 0.080***<br>(0.025)  | 0.087***<br>(0.030)  | 0.083***<br>(0.027) | 0.073**<br>(0.027)  |
| Total ads  | 237,257              | 716,067             | 237,257              | 716,067             | 123,559              | 429,527              | 123,559              | 429,527             | 115,215              | 318,274              | 115,215             | 318,274             |
| Low carbon ads   | 3,048                | 7,855               | 3,048                | 7,855               | 1,735                | 4,273                | 1,735                | 4,273               | 1,613                | 3,686                | 1,613               | 3,686               |
| R2   | 0.204                | 0.218               | 0.195                | 0.209               | 0.255                | 0.267                | 0.250                | 0.265               | 0.225                | 0.237                | 0.225               | 0.236               |
| <b>17-1 - Architects, Surveyors, and Cartographers</b> |                      |                     |                      |                     |                      |                      |                      |                     |                      |                      |                     |                     |
| Job ad is low carbon                                   | -0.241***<br>(0.021) | -0.087*<br>(0.035)  | -0.247***<br>(0.013) | -0.101<br>(0.050)   | -0.185***<br>(0.022) | -0.093***<br>(0.014) | -0.188***<br>(0.005) | -0.094**<br>(0.020) | -0.178***<br>(0.016) | -0.073**<br>(0.016)  | -0.153**<br>(0.042) | -0.079**<br>(0.021) |
| Total ads  | 6,122                | 18,958              | 6,122                | 18,958              | 2,714                | 10,815               | 2,714                | 10,815              | 3,073                | 8,072                | 3,073               | 8,072               |
| Low carbon ads   | 238                  | 678                 | 238                  | 678                 | 161                  | 483                  | 161                  | 483                 | 123                  | 308                  | 123                 | 308                 |
| R2   | 0.355                | 0.216               | 0.394                | 0.254               | 0.414                | 0.250                | 0.468                | 0.304               | 0.416                | 0.258                | 0.458               | 0.290               |
| <b>17-2 - Engineers</b>                                |                      |                     |                      |                     |                      |                      |                      |                     |                      |                      |                     |                     |
| Job ad is low carbon                                   | 0.023*<br>(0.013)    | -0.043*<br>(0.020)  | 0.017<br>(0.013)     | -0.038<br>(0.025)   | 0.030*<br>(0.017)    | -0.013**<br>(0.005)  | 0.019<br>(0.016)     | -0.006<br>(0.009)   | -0.029*<br>(0.017)   | -0.018*<br>(0.010)   | -0.034**<br>(0.014) | -0.008<br>(0.016)   |
| Total ads  | 138,328              | 205,682             | 138,328              | 205,682             | 91,005               | 149,391              | 91,005               | 149,391             | 52,030               | 80,412               | 52,030              | 80,412              |
| Low carbon ads   | 7,287                | 10,057              | 7,287                | 10,057              | 5,556                | 7,614                | 5,556                | 7,614               | 3,402                | 4,899                | 3,402               | 4,899               |
| R2   | 0.137                | 0.104               | 0.143                | 0.106               | 0.102                | 0.112                | 0.108                | 0.112               | 0.164                | 0.149                | 0.161               | 0.153               |
| <b>17-3 - Engineering and Mapping Technicians</b>      |                      |                     |                      |                     |                      |                      |                      |                     |                      |                      |                     |                     |
| Job ad is low carbon                                   | 0.130***<br>(0.030)  | 0.038***<br>(0.008) | 0.109***<br>(0.022)  | 0.041***<br>(0.010) | 0.104***<br>(0.038)  | 0.031<br>(0.020)     | 0.079***<br>(0.025)  | 0.031<br>(0.019)    | 0.102***<br>(0.022)  | 0.031**<br>(0.011)   | 0.094***<br>(0.018) | 0.033**<br>(0.011)  |
| Total ads  | 83,875               | 199,662             | 83,875               | 199,662             | 39,976               | 104,238              | 39,976               | 104,238             | 32,773               | 69,193               | 32,773              | 69,193              |
| Low carbon ads   | 1,732                | 3,745               | 1,732                | 3,745               | 1,034                | 2,337                | 1,034                | 2,337               | 791                  | 1,790                | 791                 | 1,790               |
| R2   | 0.185                | 0.140               | 0.204                | 0.159               | 0.312                | 0.231                | 0.335                | 0.258               | 0.280                | 0.205                | 0.293               | 0.223               |
| <b>19-2 - Physical Scientists</b>                      |                      |                     |                      |                     |                      |                      |                      |                     |                      |                      |                     |                     |
| Job ad is low carbon                                   | 0.071***<br>(0.004)  | -0.029<br>(0.021)   | 0.071***<br>(0.008)  | -0.011<br>(0.038)   | 0.048<br>(0.027)     | 0.006<br>(0.016)     | 0.050**<br>(0.020)   | 0.014<br>(0.026)    | 0.070***<br>(0.013)  | 0.032<br>(0.021)     | 0.070***<br>(0.010) | 0.045<br>(0.029)    |
| Total ads  | 16,775               | 25,707              | 16,775               | 25,707              | 10,994               | 18,955               | 10,994               | 18,955              | 10,416               | 13,912               | 10,416              | 13,912              |
| Low carbon ads   | 1,151                | 2,473               | 1,151                | 2,473               | 836                  | 1,909                | 836                  | 1,909               | 700                  | 1,195                | 700                 | 1,195               |
| R2   | 0.249                | 0.191               | 0.254                | 0.213               | 0.265                | 0.230                | 0.272                | 0.252               | 0.293                | 0.250                | 0.284               | 0.259               |
| <b>47 - Construction and Extraction</b>                |                      |                     |                      |                     |                      |                      |                      |                     |                      |                      |                     |                     |
| Job ad is low carbon                                   | 0.044<br>(0.053)     | -0.021*<br>(0.012)  | 0.040<br>(0.038)     | -0.014<br>(0.011)   | -0.013<br>(0.029)    | -0.002<br>(0.018)    | 0.011<br>(0.025)     | 0.006<br>(0.017)    | 0.065<br>(0.061)     | -0.013<br>(0.021)    | 0.064<br>(0.046)    | -0.004<br>(0.016)   |
| Total ads  | 98,200               | 269,768             | 98,200               | 269,768             | 22,389               | 65,878               | 22,389               | 65,878              | 41,870               | 120,945              | 41,870              | 120,945             |
| Low carbon ads   | 3,976                | 13,261              | 3,976                | 13,261              | 1,263                | 4,347                | 1,263                | 4,347               | 1,956                | 5,956                | 1,956               | 5,956               |
| R2   | 0.267                | 0.291               | 0.256                | 0.264               | 0.359                | 0.419                | 0.349                | 0.386               | 0.294                | 0.270                | 0.296               | 0.255               |
| <b>49 - Installation, Maintenance, and Repair</b>      |                      |                     |                      |                     |                      |                      |                      |                     |                      |                      |                     |                     |
| Job ad is low carbon                                   | 0.067***<br>(0.025)  | 0.040***<br>(0.006) | 0.050*<br>(0.030)    | 0.035***<br>(0.009) | 0.085***<br>(0.019)  | 0.042***<br>(0.005)  | 0.067**<br>(0.029)   | 0.043***<br>(0.009) | 0.039<br>(0.049)     | 0.018<br>(0.014)     | 0.008<br>(0.060)    | 0.030*<br>(0.017)   |
| Total ads  | 213,923              | 567,184             | 213,923              | 567,184             | 73,780               | 235,624              | 73,780               | 235,624             | 104,123              | 285,440              | 104,123             | 285,440             |
| Low carbon ads   | 5,757                | 15,376              | 5,757                | 15,376              | 2,411                | 6,651                | 2,411                | 6,651               | 3,155                | 8,439                | 3,155               | 8,439               |
| R2   | 0.149                | 0.133               | 0.172                | 0.163               | 0.263                | 0.202                | 0.284                | 0.237               | 0.197                | 0.156                | 0.240               | 0.195               |
| <b>53 - Transportation and Material Moving</b>         |                      |                     |                      |                     |                      |                      |                      |                     |                      |                      |                     |                     |
| Job ad is low carbon                                   | 0.157***<br>(0.045)  | -0.064*<br>(0.034)  | 0.108*<br>(0.063)    | -0.030<br>(0.037)   | -0.044<br>(0.078)    | 0.202***<br>(0.015)  | -0.033<br>(0.033)    | 0.154***<br>(0.038) | -0.098<br>(0.059)    | -0.100***<br>(0.022) | -0.005<br>(0.066)   | -0.046<br>(0.044)   |
| Total ads  | 349,336              | 1,489,698           | 349,336              | 1,489,698           | 74,384               | 282,924              | 74,384               | 282,924             | 151,313              | 652,591              | 151,313             | 652,591             |
| Low carbon ads   | 10,155               | 35,860              | 10,155               | 35,860              | 4,149                | 17,915               | 4,149                | 17,915              | 8,124                | 26,236               | 8,124               | 26,236              |
| R2   | 0.359                | 0.394               | 0.341                | 0.388               | 0.261                | 0.288                | 0.334                | 0.299               | 0.410                | 0.370                | 0.401               | 0.400               |
| <b>17-2 - Engineers</b>                                |                      |                     |                      |                     |                      |                      |                      |                     |                      |                      |                     |                     |
| Job ad is high carbon                                  | 0.239***<br>(0.029)  | 0.074***<br>(0.017) | 0.201***<br>(0.047)  | 0.049**<br>(0.020)  | 0.176***<br>(0.013)  | 0.049*<br>(0.025)    | 0.145***<br>(0.025)  | 0.021<br>(0.025)    | 0.219***<br>(0.047)  | 0.061***<br>(0.012)  | 0.190***<br>(0.046) | 0.041**<br>(0.017)  |
| Total ads  | 138,328              | 205,682             | 138,328              | 205,682             | 91,005               | 149,391              | 91,005               | 149,391             | 52,030               | 80,412               | 52,030              | 80,412              |
| High carbon ads  | 2,802                | 1,703               | 2,802                | 1,703               | 1,817                | 1,216                | 1,817                | 1,216               | 1,577                | 1,123                | 1,577               | 1,123               |
| R2   | 0.139                | 0.104               | 0.144                | 0.105               | 0.103                | 0.112                | 0.109                | 0.112               | 0.167                | 0.150                | 0.163               | 0.153               |
| <b>47 - Construction and Extraction</b>                |                      |                     |                      |                     |                      |                      |                      |                     |                      |                      |                     |                     |
| Job ad is high carbon                                  | 0.202**<br>(0.077)   | 0.161***<br>(0.046) | 0.152*<br>(0.085)    | 0.094<br>(0.058)    | 0.156*<br>(0.085)    | 0.099**<br>(0.046)   | 0.233***<br>(0.072)  | 0.114***<br>(0.039) | 0.183**<br>(0.080)   | 0.133***<br>(0.037)  | 0.150*<br>(0.083)   | 0.064<br>(0.057)    |
| Total ads  | 98,200               | 269,768             | 98,200               | 269,768             | 22,389               | 65,878               | 22,389               | 65,878              | 41,870               | 120,945              | 41,870              | 120,945             |
| High carbon ads  | 3,018                | 6,822               | 3,018                | 6,822               | 1,028                | 3,078                | 1,028                | 3,078               | 1,597                | 3,907                | 1,597               | 3,907               |
| R2   | 0.267                | 0.291               | 0.256                | 0.264               | 0.360                | 0.419                | 0.350                | 0.386               | 0.295                | 0.271                | 0.296               | 0.255               |
| <b>Fixed effects</b>                                   |                      |                     |                      |                     |                      |                      |                      |                     |                      |                      |                     |                     |
| Year   | Yes                  | Yes                 | Yes                  | Yes                 | Yes                  | Yes                  | Yes                  | Yes                 | Yes                  | Yes                  | Yes                 | Yes                 |
| Commuting Zone   | Yes                  | Yes                 | Yes                  | Yes                 | Yes                  | Yes                  | Yes                  | Yes                 | Yes                  | Yes                  | Yes                 | Yes                 |
| 6-digits SOC   | Yes                  | Yes                 | Yes                  | Yes                 | Yes                  | Yes                  | Yes                  | Yes                 | Yes                  | Yes                  | Yes                 | Yes                 |
| Degree   | No                   | No                  | No                   | No                  | Yes                  | Yes                  | Yes                  | Yes                 | No                   | No                   | No                  | No                  |

Table SI.25: Wage sample balance

|  | Full sample |          |              |          |           |          |            |          |        |          |
|--|-------------|----------|--------------|----------|-----------|----------|------------|----------|--------|----------|
|  | Ad count    |          | Skills count |          | Education |          | Experience |          | Salary |          |
|  | Mean        | St. Dev. | Mean         | St. Dev. | Mean      | St. Dev. | Mean       | St. Dev. | Mean   | St. Dev. |
| <b>13-1 - Business Operations Specialists</b>          |             |          |              |          |           |          |            |          |        |          |
| Generic  | 8,049,595   | 11.2     | 7.6          | 13.6     | 5.2       | 3.8      | 2.6        | 51,907   | 28,456 |          |
| Low carbon   | 78,518      | 14.7     | 8.5          | 13.9     | 5.0       | 4.2      | 2.9        | 56,544   | 28,608 |          |
| <b>17-1 - Architects, Surveyors, and Cartographers</b> |             |          |              |          |           |          |            |          |        |          |
| Generic  | 220,494     | 9.9      | 7.8          | 13.0     | 6.2       | 5.5      | 3.2        | 61,833   | 32,227 |          |
| Low carbon   | 10,473      | 15.4     | 7.9          | 14.2     | 4.6       | 5.1      | 3.5        | 60,217   | 26,033 |          |
| <b>17-2 - Engineers</b>                                |             |          |              |          |           |          |            |          |        |          |
| Generic  | 3,622,206   | 11.5     | 7.6          | 15.1     | 4.0       | 5.1      | 3.1        | 69,908   | 29,486 |          |
| High carbon  | 99,572      | 10.2     | 6.7          | 15.6     | 2.7       | 6.0      | 3.5        | 91,247   | 46,603 |          |
| Low carbon   | 180,262     | 16.0     | 8.5          | 15.3     | 3.7       | 5.3      | 3.2        | 68,407   | 25,775 |          |
| <b>17-3 - Engineering and Mapping Technicians</b>      |             |          |              |          |           |          |            |          |        |          |
| Generic  | 1,897,103   | 9.0      | 6.9          | 11.5     | 5.1       | 3.7      | 2.7        | 40,981   | 20,903 |          |
| Low carbon   | 42,653      | 14.3     | 8.1          | 12.6     | 4.4       | 4.3      | 2.9        | 46,951   | 21,085 |          |
| <b>19-2 - Physical Scientists</b>                      |             |          |              |          |           |          |            |          |        |          |
| Generic  | 343,905     | 10.7     | 6.8          | 16.1     | 3.9       | 4.3      | 3.2        | 57,392   | 31,584 |          |
| Low carbon   | 20,059      | 15.5     | 8.5          | 16.0     | 3.9       | 4.4      | 3.2        | 55,245   | 23,128 |          |
| <b>47 - Construction and Extraction</b>                |             |          |              |          |           |          |            |          |        |          |
| Generic  | 1,793,801   | 5.9      | 5.6          | 6.9      | 6.2       | 3.7      | 2.5        | 39,470   | 22,710 |          |
| High carbon  | 110,232     | 7.5      | 6.2          | 10.9     | 4.8       | 3.1      | 2.6        | 43,132   | 25,198 |          |
| Low carbon   | 94,710      | 10.0     | 7.3          | 8.3      | 5.9       | 3.4      | 2.4        | 42,603   | 24,160 |          |
| <b>49 - Installation, Maintenance, and Repair</b>      |             |          |              |          |           |          |            |          |        |          |
| Generic  | 5,738,508   | 8.1      | 6.4          | 9.5      | 5.3       | 3.1      | 2.3        | 39,648   | 22,171 |          |
| Low carbon   | 170,465     | 13.0     | 7.5          | 9.0      | 5.6       | 3.0      | 2.4        | 43,841   | 21,256 |          |
| <b>53 - Transportation and Material Moving</b>         |             |          |              |          |           |          |            |          |        |          |
| Generic  | 10,793,119  | 2.9      | 3.5          | 6.7      | 6.1       | 2.1      | 2.2        | 49,595   | 38,542 |          |
| Low carbon   | 201,256     | 4.7      | 4.5          | 9.3      | 5.1       | 2.4      | 2.1        | 40,273   | 29,481 |          |

|  | Has wage information |          |              |           |          |           |           |          |            |            |          |        |  |
|--|----------------------|----------|--------------|-----------|----------|-----------|-----------|----------|------------|------------|----------|--------|--|
|  | Ad count             |          | Skills count |           |          | Education |           |          | Experience |            |          | Salary |  |
|  | Mean                 | St. Dev. | t-test       | Mean      | St. Dev. | t-test    | Mean      | St. Dev. | t-test     | Mean       | St. Dev. |        |  |
| <b>13-1 - Business Operations Specialists</b>          |                      |          |              |           |          |           |           |          |            |            |          |        |  |
| Generic  | 1,430,951            | 10.3     | 7.2          | -0.849*** | 12.2     | 6.4       | -1.42***  | 3.2      | 2.4        | -0.574***  | 51,907   | 28,456 |  |
| Low carbon   | 16,915               | 14.0     | 8.7          | -0.699*** | 11.9     | 6.8       | -1.95***  | 3.3      | 2.6        | -0.893***  | 56,544   | 28,608 |  |
| <b>17-1 - Architects, Surveyors, and Cartographers</b> |                      |          |              |           |          |           |           |          |            |            |          |        |  |
| Generic  | 37,012               | 10.0     | 7.8          | 0.0913**  | 12.0     | 6.8       | -1.04***  | 4.5      | 2.9        | -0.99***   | 61,833   | 32,227 |  |
| Low carbon   | 1,463                | 15.9     | 8.2          | 0.488**   | 13.6     | 5.5       | -0.585*** | 4.4      | 3.1        | -0.734***  | 60,217   | 26,033 |  |
| <b>17-2 - Engineers</b>                                |                      |          |              |           |          |           |           |          |            |            |          |        |  |
| Generic  | 521,104              | 10.8     | 7.5          | -0.637*** | 14.7     | 4.5       | -0.41***  | 4.5      | 3.0        | -0.689***  | 69,908   | 29,486 |  |
| High carbon  | 7,548                | 8.7      | 6.9          | -1.51***  | 15.1     | 3.9       | -0.509*** | 6.0      | 3.6        | -0.0536    | 91,247   | 46,603 |  |
| Low carbon   | 27,409               | 16.2     | 9.3          | 0.167***  | 14.9     | 4.2       | -0.373*** | 4.3      | 3.2        | -0.967***  | 68,407   | 25,775 |  |
| <b>17-3 - Engineering and Mapping Technicians</b>      |                      |          |              |           |          |           |           |          |            |            |          |        |  |
| Generic  | 435,558              | 8.3      | 6.5          | -0.707*** | 10.2     | 5.8       | -1.37***  | 3.1      | 2.5        | -0.632***  | 40,981   | 20,903 |  |
| Low carbon   | 8,470                | 13.7     | 9.1          | -0.583*** | 11.4     | 5.3       | -1.24***  | 3.6      | 2.6        | -0.743***  | 46,951   | 21,085 |  |
| <b>19-2 - Physical Scientists</b>                      |                      |          |              |           |          |           |           |          |            |            |          |        |  |
| Generic  | 65,362               | 10.3     | 6.9          | -0.371*** | 15.2     | 4.9       | -0.889*** | 3.1      | 2.7        | -1.2***    | 57,392   | 31,584 |  |
| Low carbon   | 6,480                | 16.7     | 9.0          | 1.18***   | 15.2     | 4.8       | -0.746*** | 3.1      | 2.5        | -1.31***   | 55,245   | 23,128 |  |
| <b>47 - Construction and Extraction</b>                |                      |          |              |           |          |           |           |          |            |            |          |        |  |
| Generic  | 530,065              | 5.8      | 5.5          | -0.099*** | 5.6      | 6.2       | -1.33***  | 3.5      | 2.4        | -0.227***  | 39,470   | 22,710 |  |
| High carbon  | 14,620               | 6.0      | 5.6          | -1.45***  | 8.6      | 6.1       | -2.31***  | 3.2      | 2.6        | 0.15***    | 43,132   | 25,198 |  |
| Low carbon   | 27,894               | 9.5      | 7.8          | -0.483*** | 6.9      | 6.2       | -1.35***  | 3.1      | 2.2        | -0.261***  | 42,603   | 24,160 |  |
| <b>49 - Installation, Maintenance, and Repair</b>      |                      |          |              |           |          |           |           |          |            |            |          |        |  |
| Generic  | 1,162,640            | 7.8      | 6.2          | -0.311*** | 7.9      | 6.0       | -1.6***   | 3.0      | 2.2        | -0.091***  | 39,648   | 22,171 |  |
| Low carbon   | 33,261               | 12.9     | 8.4          | -0.173*** | 8.4      | 5.8       | -0.624*** | 3.3      | 2.4        | 0.255***   | 43,841   | 21,256 |  |
| <b>53 - Transportation and Material Moving</b>         |                      |          |              |           |          |           |           |          |            |            |          |        |  |
| Generic  | 3,146,085            | 2.6      | 3.0          | -0.352*** | 4.9      | 6.0       | -1.82***  | 2.2      | 2.2        | 0.0705***  | 49,595   | 38,542 |  |
| Low carbon   | 72,108               | 4.7      | 4.8          | 0.0168    | 8.8      | 5.4       | -0.51***  | 2.3      | 2.2        | -0.0805*** | 40,273   | 29,481 |  |



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