Virtual Seminar on Climate Economics

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

with Misato Sato and Francesco Vona

Aurélien Saussay

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January 19th, 2023
Policy objective to create jobs through climate mitigation

President Obama’s 2008 campaign sought to create “5 million ‘green’ jobs”

President Biden promises that his focus on environment will be “jobs, jobs, jobs”
Mitigation requires shifting away from fossil industries

Phasing out fossil fuels jeopardizes the livelihood of communities that depend of fossil-fuel extraction and fossil-intensive industries
Low carbon jobs are difficult to observe unlike ‘dirty’ jobs

• Widespread across sectors, occupations, geography
• New, and changing
⇒ Lack of agreed definition, classification and data

• Concentrated
• Well established

Public debate exaggerates the job killing argument while downplaying the job creation effect of the low-carbon transition
How to define green job and green skills?

- **No agreed definition** of green jobs or green skills
  - Green sectors? Green firms? Green activities? Green workers?

- A **working definition** of green jobs needs to **account** for the **skills profile** of green jobs

- Why focus on **green skills**?
  - Evaluate the **skill gap** between newly created green jobs and jobs destroyed by environmental regulation (brown jobs) to evaluate the possibility of re-employing displaced workers
  - Consider the need of **complementary educational** and **training policies** to be combined with environmental policies
BLS Green Jobs Initiative (2010)

- **BLS program** initiated in 2010 to help measure for **green jobs**:
  - **Number** of and **trend** over time
  - **Industrial**, **occupational**, and **geographic distribution**
  - **Wages**

- **Output** approach: who produces green **goods**?

- **Process** approach: who uses green **processes**?

- **O*NET Green Task Development Project** (2010) identified:
  - 1,369 **green tasks**
  - Added green tasks to **105 existing occupations**
  - 33 new and emerging green **occupations**
Combining task-based approach with the O*NET dataset

- First data driven methodology

- Measure occupation level exposure to green technologies and productions: share of green tasks over total tasks (Vona et al., 2018, 2019)

- Data-driven identification of green skills (Vona et al., 2018) and assessing direct and indirect green jobs (multiplier effects) (Bowen et al., 2018; Vona et al., 2019)

- Using exogenous policy variation to examine the effect of policies on demand for green skills (Vona et al., 2018; Popp et al., 2021; Marin and Vona, 2019; Vona et al., 2019)
Key insights gained

▶ **Green** occupations require **more on the job training** are slightly more **non-routine** cognitive than non-green occupations (Consoli et al., 2016)

▶ Green occupations require **more technical, engineering, monitoring and managerial** skills. (Vona et al., 2018)

▶ **Winners** (technicians, engineers) and **losers** (manual workers) from the green transition (Marin and Vona, 2019)

▶ Effect of **green subsidies** strongly mediated by the **local availability** of **green skills** (Popp et al., 2021)

▶ **Limitations** of the **O*NET** data on green jobs (i.e., Green Economy Program)
  ▶ Can’t precisely observe green jobs **within an occupation**
  ▶ Difficult to conduct **more granular analysis** for specific technologies or occupations
  ▶ Data updated **infrequently**
Going more granular
Our approach: Skill-based, using job level data

- Advantages of job level data
  - Move from occupational level to job level data on skill profiles
  - Examine skills gaps within an occupational group

- Lightcast dataset comprising all job advertisements in the United States over 2010-2019
  - 196 million job ads
  - Occupation
  - Skills required
  - Salary offered
  - Education requirements

- Workers more likely to transition towards green jobs within the same occupational group
Relation to the literature

- **Identifying green jobs**
  Vona et al. (NBER 2015); Vona et al. (JAERE, 2018); Bowen et al. (EE, 2018); Vona et al. (JEconGeo, 2019); Curtis & Marinescu (NBER, 2022)

- **Labour market impacts of environmental policies**
  Greenstone (JPE, 2002); Kahn & Mansur (JPubE, 2013); Hafstead & Williams (JPubE 2018); Marin et al. (ERE, 2018); Castellanos & Heutel (NBER, 2019); Marin & Vona (JEEM, 2019)

- **Labour market adjustments to technological change**
  Hershbein & Kahn (AER, 2018); Deming & Kahn (JLE, 2018); Gathmann & Schoenberg (JLE, 2010); Atalay et al., (AEJ: AE, 2018)
The Lightcast dataset
Number of ads collected has doubled since 2010
High skilled occupations are over-represented
What’s in an ad?

- Example: Chemical Engineer job offered in Sunnyvale, CA in 2018
  - MSc required
  - 3 years of experience
  - Starts at $118k

- Job ads are represented as a set of *skills*

<table>
<thead>
<tr>
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<th>Quality Assurance and Control</th>
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</table>

- BG reports more than 16,000 distinct skills

- We apply **Natural Language Processing** (NLP) and **expert elicitation** to identify **green skills**
Highly heterogeneous skill vector length across occupations

Aurélien Saussay, Misato Sato, Francesco Vona
Identifying low carbon skills
Identifying core low carbon skills

- Need to identify **skills** that are characteristic of the **core low carbon** (climate-related) occupations

**Keywords source** → **NLP** → **Expert survey** → **Core low carbon skills**

- Obtain **source text** from which to extract **low carbon keywords**
- **Green tasks** associated with **climate-related** occupations in **O*NET** (subset of Green Economy)
  - “Calculate potential for energy savings.”
  - “Fabricate prototypes of fuel cell components, assemblies, or systems.”
  - “Test wind turbine components, by mechanical or electronic testing.”
- **Green products** descriptions from **PRODCOM**
Identifying core low carbon skills

- Need to identify **skills** that are characteristic of the **core low carbon** (climate-related) occupations

- Use **natural language processing** to extract **low carbon keywords**

- **Unsupervised machine learning** using **TF-IDF**

- **Semantically matched** against BG skills using **word embeddings** (Word2Vec)

- Yields a **“greeness” score** between 0 and 1

- **Perfect semantic matches** against top 20 keywords are considered core low carbon: 396 skills
Identifying core low carbon skills

▶ Need to identify **skills** that are characteristic of the **core low carbon** (climate-related) occupations

Keywords source → NLP → **Expert survey** → Core low carbon skills

▶ High scoring skills are potentially core low carbon, but must be **inspected manually**

▶ **Supervised** portion of our selection algorithm

▶ **Surveyed 60+ experts** from LSE, Oxford, OECD, University of Venice among others to review 600 high scoring skills

▶ **51** skills were selected
Identifying core low carbon skills

- Need to identify **skills** that are characteristic of the **core low carbon** (climate-related) occupations

Keywords source → NLP → Expert survey → Core low carbon skills

- **447 core low carbon skills**
  - “Solar Energy Components”
  - “Wind Energy Engineering”
  - “Light Rail Transit Systems”
  - “Clean Air Act”

- Each of the 16,000 skills is classified as **low carbon** (climate-related) or **generic**
What’s in an ad? Green skill edition

- Example: Chemical Engineer job offered in Sunnyvale, CA in 2018
  - MSc required
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  - Starts at $118k

- Job ads are represented as a set of skills

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Results
Low carbon jobs’ share has not increased since 2010
Low carbon ads are concentrated in 6 major SOC groups

- Transportation and Material Moving
- Production
- Installation, Maintenance, and Repair
- Construction and Extraction
- Farming, Fishing, and Forestry
- Office and Administrative Support
- Sales and Related
- Personal Care and Service
- Building and Grounds Cleaning and Maintenance
- Food Preparation and Serving Related
- Protective Service
- Healthcare Support
- Healthcare Practitioners and Technical
- Legal
- Education, Training, and Library
- Arts, Design, Entertainment, Sports, and Media
- Architecture and Engineering
- Computer and Mathematical
- Business and Financial Operations
- Management

Share of low-carbon ads by occupation (2010-2019)
Evolution of low carbon share across occupations
Skill gaps are larger and broader in high-skilled occupations.
Heterogeneous skills gap in low-skilled occupations

- 47 – Construction and Extraction
- 49 – Installation, Maintenance, and Repair
- 53 – Transportation and Material Moving

<table>
<thead>
<tr>
<th>Category</th>
<th>Cognitive</th>
<th>IT</th>
<th>Management</th>
<th>Social</th>
<th>Technical</th>
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</thead>
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<tr>
<td>47 – Construction and Extraction</td>
<td><img src="#" alt="Cognitive" /></td>
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</table>

- Generic
- High carbon
- Low carbon
Specialization vs diversification by occupation

Define low and high-carbon skill coreness indices:

\[ G_{s}^{SOC} = \frac{g_{s}^{SOC} - 1}{g_{s}^{SOC} + 1} \]

\[ g_{s}^{SOC} = \frac{n_{s}^{SOC}}{n^{SOC}} / \frac{n_{s}}{n} \]

\[ C_{s}^{SOC} = \frac{c_{s}^{SOC} - 1}{c_{s}^{SOC} + 1} \]

\[ c_{s}^{SOC} = \frac{n_{c,s}^{SOC}}{n^{c,SOC}} / \frac{n_{s}^{SOC}}{n^{SOC}} \]

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

\( n_{c,s}^{SOC} \) 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 \( SOC \)
Specialization vs diversification by occupation

Aurélien Saussay, Misato Sato, Francesco Vona
The green wage premium has vanished over the decade

Aurélien Saussay, Misato Sato, Francesco Vona
Limited overlap between low and high-carbon low-skilled jobs

Low carbon ads vs high carbon vacancies

Low carbon ads vs high carbon jobs

Share of low carbon ads
- 0% to 0.6%
- 0.6% to 0.9%
- 0.9% to 1.1%
- 1.1% to 1.5%
- 1.5% or more

High carbon ads / employment
- Top 15% commuting zones

Aurélien Saussay, Misato Sato, Francesco Vona
Low carbon jobs are created in relatively richer areas

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

<table>
<thead>
<tr>
<th>Low skill</th>
<th>Unweighted</th>
<th>Weighted by ad count</th>
<th>Weighted by population</th>
</tr>
</thead>
<tbody>
<tr>
<td>log($inc_{cz}$)</td>
<td>0.006***</td>
<td>0.002*</td>
<td>0.002**</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>Observations</td>
<td>685</td>
<td>685</td>
<td>685</td>
</tr>
<tr>
<td>R2</td>
<td>0.03</td>
<td>0.01</td>
<td>0.02</td>
</tr>
<tr>
<td>AIC</td>
<td>-4.974</td>
<td>-4.960</td>
<td>-4.961</td>
</tr>
</tbody>
</table>

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

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<tr>
<td>log($inc_{cz}$)</td>
<td>0.007***</td>
<td>-0.001**</td>
<td>-0.001***</td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
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<td>647</td>
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<td>0.03</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>AIC</td>
<td>-4.522</td>
<td>-4.456</td>
<td>-4.459</td>
</tr>
</tbody>
</table>
Conclusions

- No increase in the overall demand for low carbon jobs over the past decade in the US
  - Increase in low skill occupations, decrease in high skill occupations
- Low carbon jobs require more skills
  - Skill gap more pronounced in high-skilled occupations, and for social, management, and technical skills
  - Emerging skill gap larger and broader than previously considered
- The low carbon wage premium has eroded over time
- Lack of a wage premium for low carbon jobs despite higher skills requirements is problematic for their attractiveness
- Powerful, replicable tool to monitor, evaluate many aspects of labour market consequences of the low-carbon transition
Follow-up: UK extension
Low carbon ad share: similar to US levels, but different trends
Low carbon share for selected SOC groups

- 53 − Skilled Construction And Building Trades
- 81 − Process, Plant And Machine Operatives
- 82 − Transport And Mobile Machine Drivers And Operatives
- 311 − Science, Engineering And Production Technicians
- 312 − Draughtspersons And Related Architectural Technicians
- 52 − Skilled Metal, Electrical And Electronic Trades
- 211 − Natural And Social Science Professionals
- 212 − Engineering Professionals
- 243 − Architects, Town Planners And Surveyors

Graphs show the percentage of low carbon share over years 2012 to 2020, weighted and unweighted by LFS employment.
Spatial patterns: Low carbon job ad share

Notes: For each Travel to Work Area (TTWA), we calculate the (unweighted) average of low carbon ad shares across all 4-digit SOC occupations within each skill category. TTWAs approximate local labour market areas. The TTWAs with hashed orange overlay indicates those with a high share (top 15%) of high carbon job ads for that skill level. High skill occupations are those in SOC major groups 1, 2, and 3; middle skill occupations are in SOC major groups 4 and 5; low skill occupations are in SOC major groups 6, 7, 8, and 9.
Low carbon wage gap by SOC group

211 – Natural And Social Science Professionals
212 – Engineering Professionals
243 – Architects, Town Planners And Surveyors
311 – Science, Engineering And Production Technicians
52 – Skilled Metal, Electrical And Electronic Trades
53 – Skilled Construction And Building Trades
81 – Process, Plant And Machine Operatives
82 – Transport And Mobile Machine Drivers And Operatives

Years
• 2012–2015
▲ 2018–2021

Low carbon job ads wage gap

High carbon job ads wage gap

Aurélien Saussay, Misato Sato, Francesco Vona
1. Low carbon jobs **declined** between 2012-2018 as **green policies** were **killed off** (e.g. onshore wind support, green investment bank, green deal, zero carbon homes)

2. **Growth** in **middle** and **high skilled** low carbon jobs since 2018 but **not low skilled**

3. **Spatial correlation** between **high** and **low carbon jobs**, especially for low skilled but also for high skilled (Scotland)

4. **Green wage premium** has generally **disappeared** in recent years. Some exceptions e.g. Managers and directors (high), skilled construction trade (middle), machine operatives (low)

5. Both green and brown jobs require **more skills than generic jobs**, across all broad skill groups
Appendix
What’s in an ad?

- Example: Chemical Engineer job offered in Sunnyvale, CA in 2018
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- Job ads are represented as a set of *skills*

  - Cost Control
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  - **Fuel Cell**
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  - Biotechnology
  - Six Sigma
  - Machine Operation
  - Manufacturing Processes
  - Biotechnology Product Development
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