Beyond Green Jobs: How Climate Policies Reshape Skill Demand

Angelica Bertucci, Emilio Colombo, Patrizio Tirelli

May 25, 2026

Overview

Climate Change Policies and Labour Markets

Motivation

- **Climate Change Policies (CCPs)** are environmental measures aimed at supporting the green transition, improving energy efficiency, and reducing emissions.
- These policies include carbon taxes, subsidies for renewable energy, emissions regulations, and support for green R&D.
- CCPs have sparked an **intense political debate**: CCPs as "job killers" ("jobs versus environment" controversy) or opportunity for a reskilling.

Research Questions

1. Do CCPs affect the behaviour (labour demand) of firms ?
   - What are the responses of online job postings to CCPs?
   - Do climate policy shocks induce reallocation toward greener jobs?
2. What are the effects on labour market dynamics and on the macroeconomic system?

Literature

Two strands of literature:
Labour Market Effects

- [Vona et al.(2018)Vona, Marin, Consoli and Popp]: Green transition demands technical/engineering skills.
- [Saussay et al.(2022)Saussay, Sato, Vona and O'Kane], [Dept.(2022)]: Reallocation is costly; mobility across green/brown jobs is limited.
- [Causa et al.(2024)Causa, Nguyen and Soldani]: Green/brown job shares stable (EU, 2009–2019); limited signs of green transition.

Aggregate Effects

- Mild macro impacts from energy price shocks: [Baqaee and Farhi(2019)], [Baqaee and Farhi(2022)], [Bachmann et al.(2022)Bachmann, Baqaee, Bayer, Kuhn, Löschel, Moll, Peichl, Pittel an [Chafwehé et al.(2024)Chafwehé, Colciago and Priftis].
- Carbon taxes show no significant GDP effect: [Metcalf(2019), Metcalf and Stock(2020a), Metcalf and Stock(2020b), Bernard and Kichian(2021)].
- Some inflationary and depressive effects: [Berthold et al.(2023)Berthold, Cesa-Bianchi, Di Pace and Haberis], [Känzig(2023)], [Bettarelli et al.(2024)Bettarelli, Furceri, Mazzola, Pizzuto and Yarveisi].

Preview of Results

Main finding preview $\rightarrow$ in Italy (2013-2019)

1. Online job postings increase permanently in response to CCPs
2. The demand for Green Jobs increases unambiguously in response to CCPs
3. The positive impact on job posting is greater for *"Green"* occupations.
4. CCPs affect labour market dynamism (turnover)
5. CCPs have a contractionary effect on the macroeconomic system

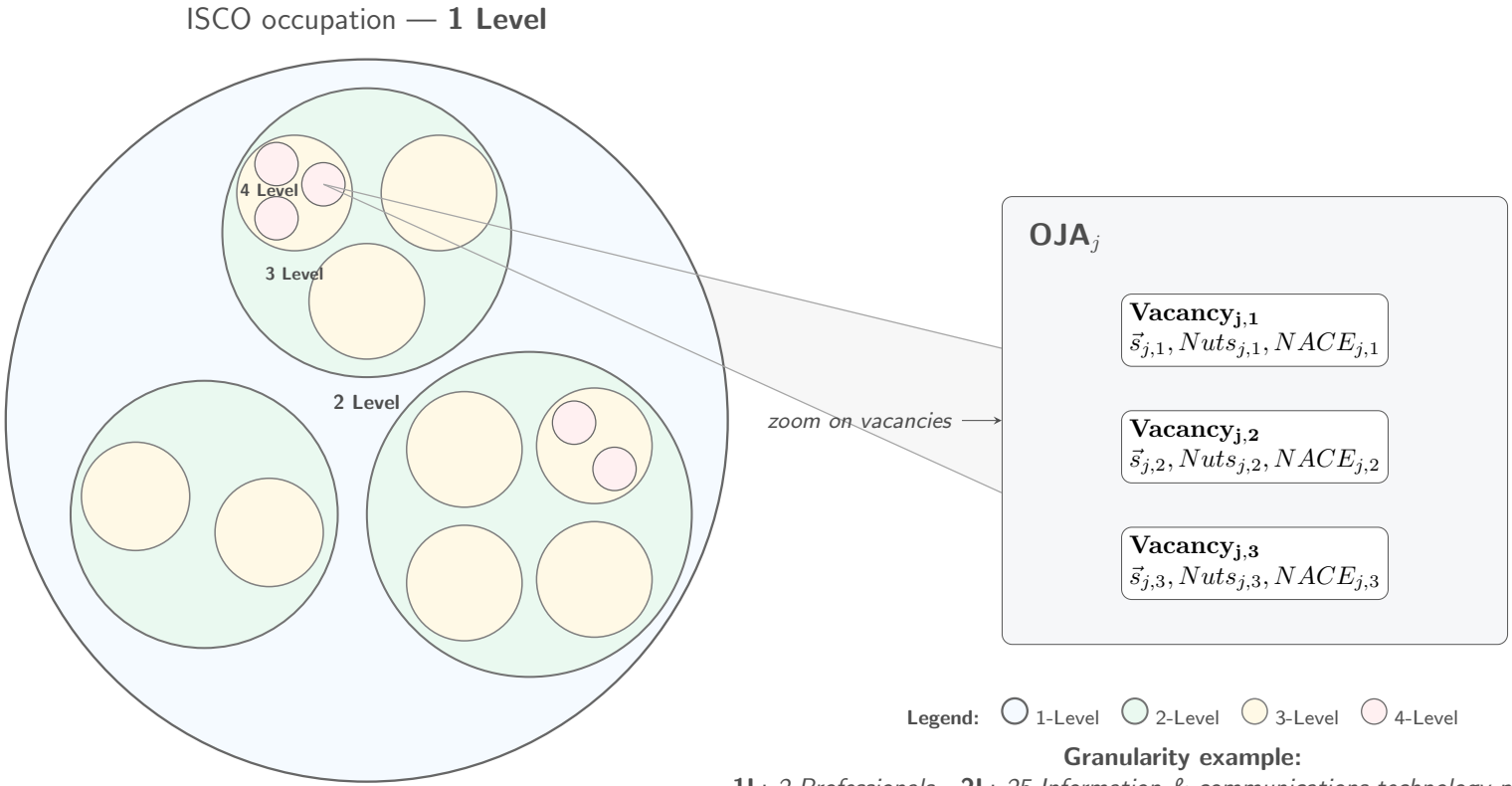
Climate Policy Measures: Indices Overview

- **Environmental Policy Stringency Index (EPS)** Developed by the OECD (*Botta & Kozluk, OECD (2014)*), it measures the degree of stringency of (national) environmental regulations using a composite of:
  - Market-based instruments (e.g., taxes, tradable permits)
  - Non-market-based instruments (e.g., performance standards)
  - Technology support (e.g., subsidies, R&D incentives)
  - We use market based measures
- **Emissions-weighted Carbon Price (ECP)** (*Dolphin & Merkle (2024)*) Reflects the effective price of (national) CO_2 emissions across sectors, weighted by emissions volume, covering taxes and trading systems.
- **Kanzig Carbon Policy Shock**: captures changes in expectations about future carbon costs—driven by policy announcements or regulatory signals affecting carbon pricing mechanisms (Eu level).

Online Job Advertisements (OJAs)

- Data from Lightcast (2013–2019), based on job boards, public/private services, and newspapers.
- Approx 500K OJAs per year, across 400 occupations in Italy.
- Unlike task-based approaches (e.g., O*NET), we identify green content at the **skill level**.
- Classified by ISCO occupation codes; skills mapped using ESCO and CEDEFOP taxonomies.
- Green skills: energy efficiency, pollution control, resource management, and sustainable technologies.

→ Capture changes *within-occupation*



Granularity example:

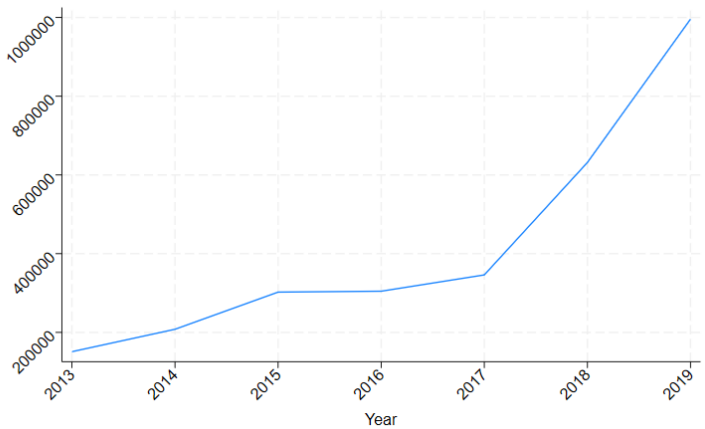
1L: *2 Professionals* **2L**: *25 Information & communications technology professionals*
3L: *251 Software and applications developers and analysts* **4L**: *2511 System Analysts*

Trends in OJAs and Green Skills

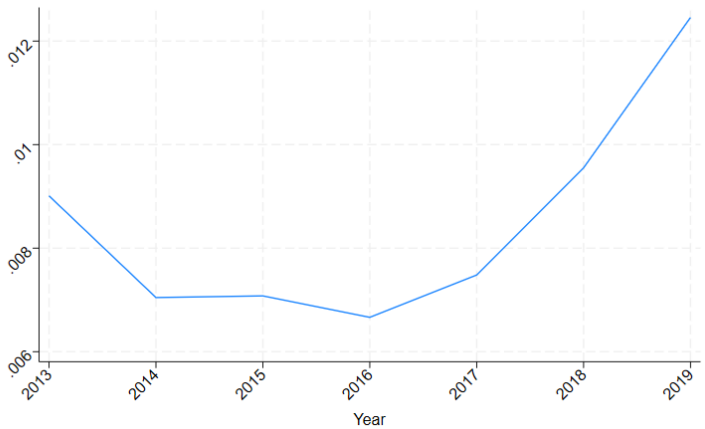
Strong upward trend in both total and green OJAs (mainly after 2017).

OJA outcome variables

Figure: OJA and Green OJA Trends (2013–2019)



(a) Total vacancies



(b) Share of green vacancies

Data and Outcome Variables

Back **Data coverage:** Italy, 2013–2019 — annual panel at regional level (NUTS-2)

Three main sets of outcome variables:

1. **Job Postings and Green Job Postings**
   - The total number of online vacancies (*Total vacancies*).
   - The number of vacancies that require at least one *green skill* (*Green vacancies*).
   - The total number of green skills identified in the occupation (*Total green skills*).
   - *Green skill variety* that captures the variability of skills within each specific group. N. of unique distinct skills
   - The number of vacancies that require no *green skills* (*Brown vacancies*).
   - The ratio between *Total green skills* and the total number of skills identified in the vacancies (*Green/Total skill ratio*)
2. **Regional Labour Market (and Macroeconomic) Indicators**
   - Employment, unemployment rate, hours worked

Green and digital occupations

Vacancies are classified in occupations. Can we define an occupation as green? We use a data driven approach using the Revealed Comparative Advantage. We define the Green *RCA* as:

$$GRCA_{D,j} = \frac{\frac{\sum_{j=1}^{G} S_{ij}}{\sum_{j=1}^{n} S_{ij}}}{\frac{\sum_{i=1}^{m}\sum_{j=1}^{G} S_{ij}}{\sum_{i=1}^{m}\sum_{j=1}^{n} S_{ij}}} \quad (1)$$

where $i = 1...m$, and $j = 1...n$, respectively define occupation and skill sets; $i = 1...G, G < m$, defines the subset of green skills, and $S_{i,j}$ defines skill j in occupation i.
The numerator is the specialisation of a certain occupation i in the group of green skills (characterised by $j \in G$). The denominator defines the average specialisation of the market.
Thus, if $GRCA > 1$, the occupation is intensive in green skills. We build a similar measure for *Digital* skills.

Addressing Endogeneity in Climate Policy Shocks

- The ECP and EPS indexes may suffer from potential problems of **endogeneity**, mainly due to **omitted variable bias**.
- Common factors (e.g. macroeconomic conditions, public attention to climate change) may simultaneously influence both the **stringency of climate policies** and the **labor market outcomes** (e.g. posted vacancies).
- To mitigate this issue:
  - We employ in addition the **Känzig (2023) carbon policy shock**
  - We estimate an **Instrumental Variables (IV)** specification using a **two-stage approach** to further address potential endogeneity concerns.
  - ECP and EPS are instrumented with 3 components of the World Risk Index: *Exposure* (to natural hazards such as earthquakes, hurricanes, floods, etc.), *Vulnerability* and *Susceptibility* (both depending on infrastructure, nutrition, housing situation, etc.).

Model and Estimation Approach

We estimate a dynamic panel model (for ECP and EPS indexes):

$$Y_{i,s,r,t} = \beta_0 + \beta_1 Y_{i,s,r,t-1} + \beta_2 \text{CCP}_t + \beta_3 \text{CCP}_{t-1} + \gamma_t + \alpha_i + \alpha_s + \alpha_r + \varepsilon_{irt}$$

and a local projection specification (Jordà, 2005) for the Kanzig carbon policy shock:

$$Y_{i,s,r,t+h} = \beta_{0,h} + \sum_{j=1}^{n} \beta_{j,h}^{y} Y_{i,s,r,t-j} + \sum_{j=1}^{z} \beta_{j,h}^{k} \text{KShock}_{t-j} + \gamma_t + \alpha_i + \alpha_s + \alpha_r + \varepsilon_{isrt+h}$$

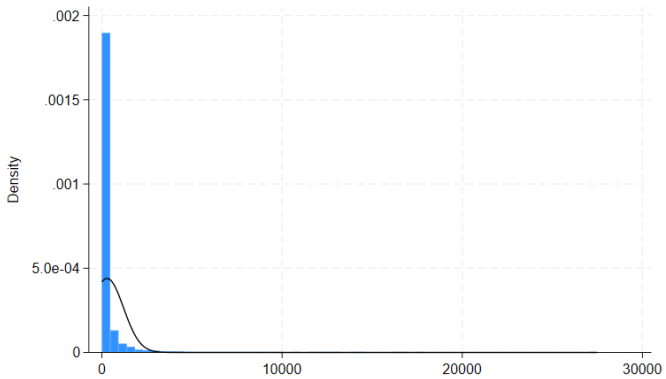
- Indices: i = occupation (ISCO 3-digit), s = sector, r = region (NUTS2), t = quarter/month/year.
- Fixed effects: occupation (α_i), sector (α_s), region (α_r) (only region for lm and macro variables).
- Horizon h: up to **16 quarters** (4 years).
- γ_t linear time trend; errors clustered at NUTS-2 level

Model and Estimation Approach

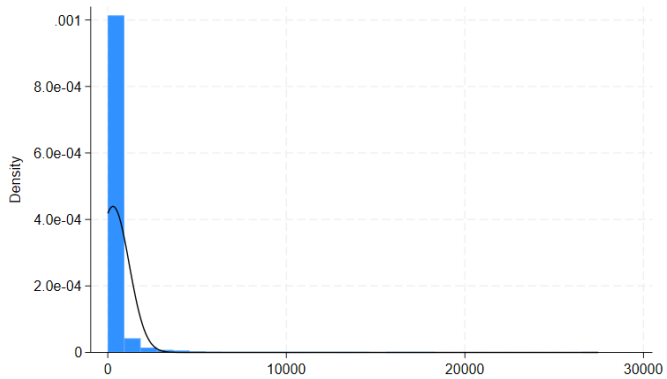
Estimation methods:

- **Vacancy data (OJAs):** Estimated via *Poisson* estimation due to many zeros and left-skewed distribution.

Figure: Variable distribution vs. normal



(a) Total Online Vacancies aggregated at isco-3 level



(b) green Online Vacancies aggregated at isco-3 level

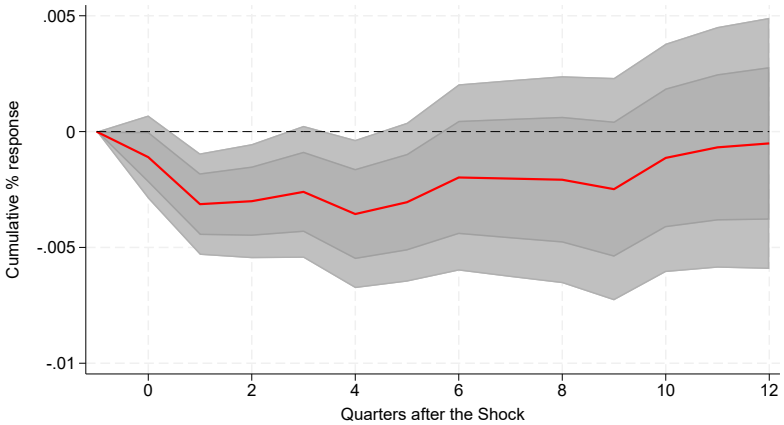
- **Macro and flow variables:** Log-transformed and estimated via *Ordinary Least Squares (OLS)*.

Macro and Labour Market Responses

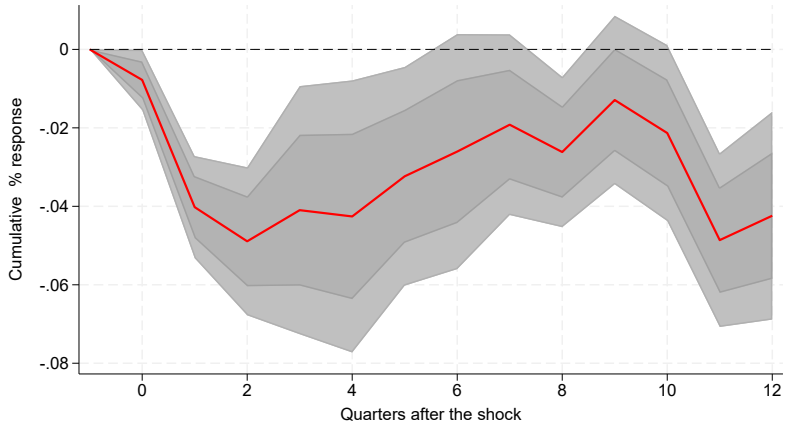
- **ECP** and **EPS** are **contractionary** over 2013–2019: total employment, hours worked, GDP decrease, unemployment rate rises
- **Kanzig shock** confirms results, with an impact bigger in magnitude just wrt ECP index

Following Kanzig (2025) → national policies are less effective beacuse of fiscal policy, monetary policy, spillovers, pass-trough.

Employment and hirings

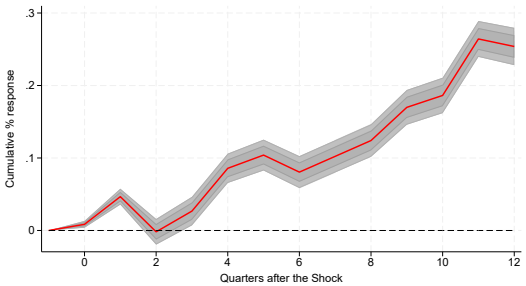


(a) Employment

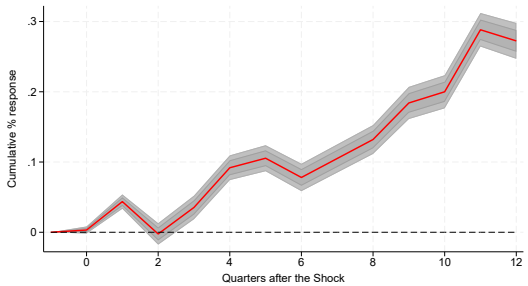


(b) Hirings

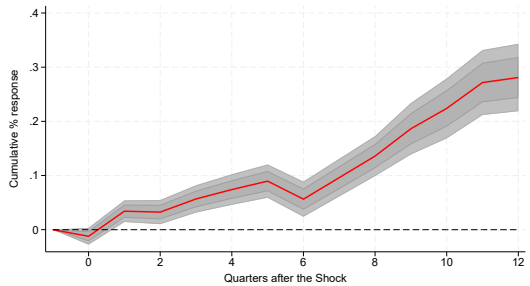
Vacancies, green and brown



(a) Total Vacancies

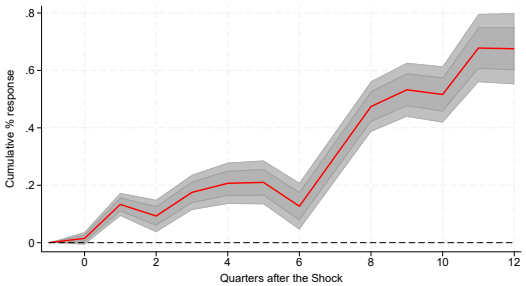


(b) Brown Vacancies

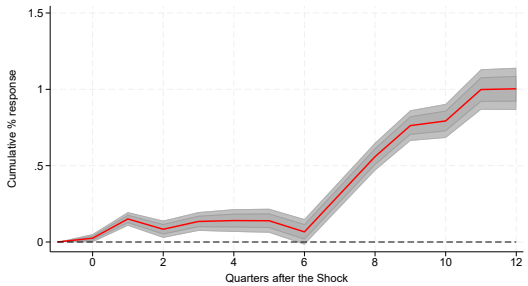


(c) Green Vacancies (share of Total Vacancies)

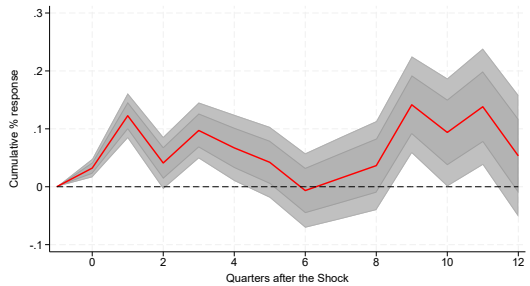
Green skills



(a) Total Green Skills

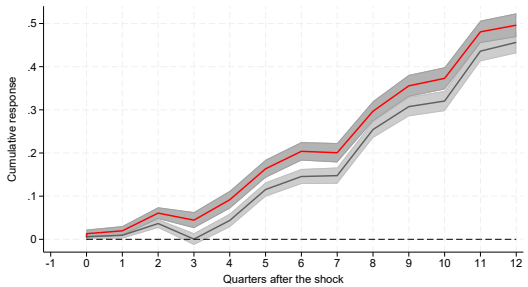


(b) Total Green Skills (share of Total Skills)

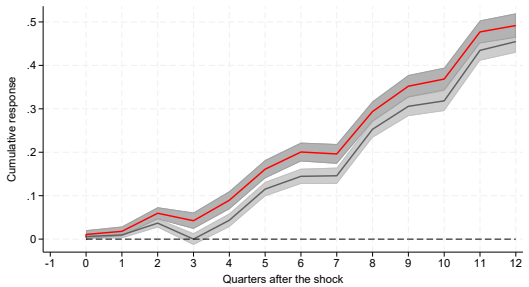


(c) Green Skill Variety

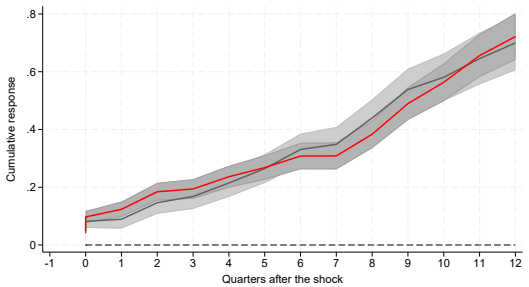
Green skills in green occupations



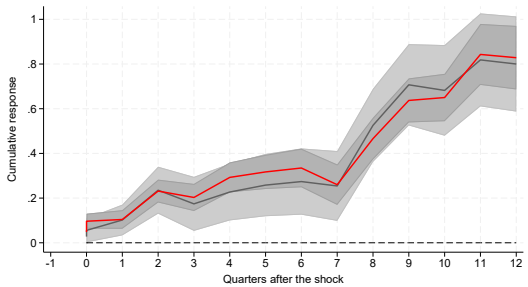
(a) Total Vacancies



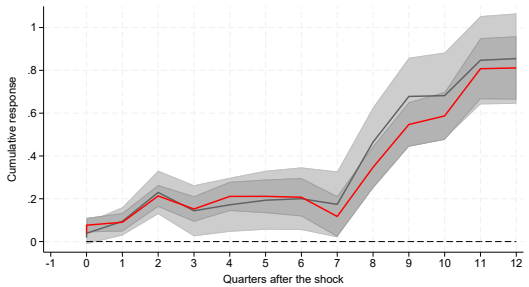
(b) Brown Vacancies



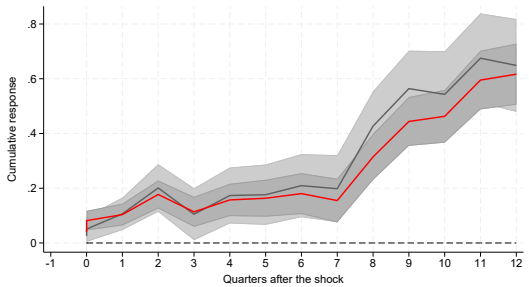
(c) Green Vacancies



(a) Total Green Skills per Vacancy



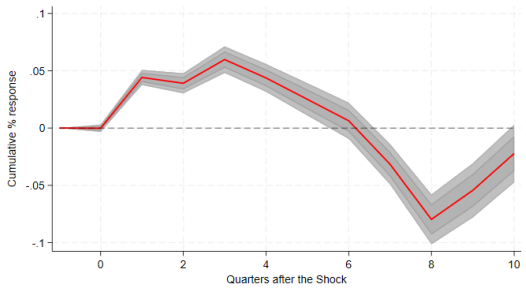
(b) Total Green Skills (share of Total Skills)



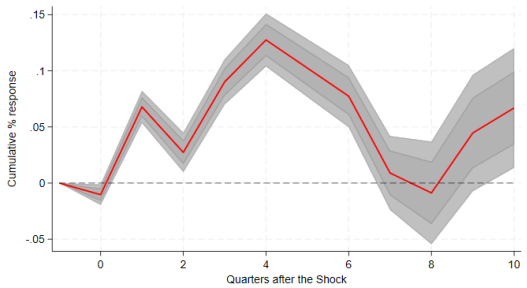
(c) Green Skill Variety

Red line: green occupations, black line: non green occupations.

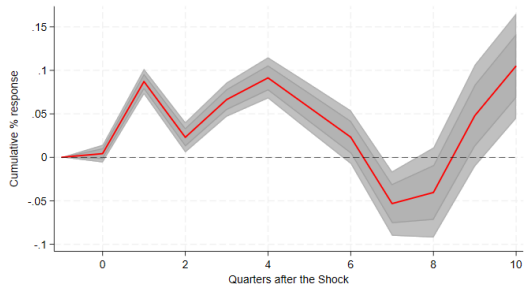
Digital vacancies



(a) Digital Vacancies (share of Total Vacancies)

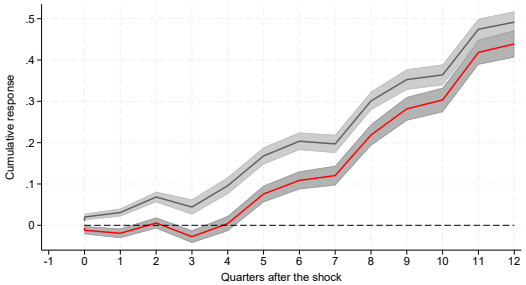


(b) Total Digital Skills per Vacancy

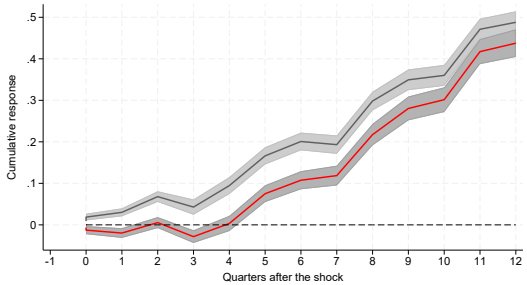


(c) Total Digital Skills (share of Total Skills)

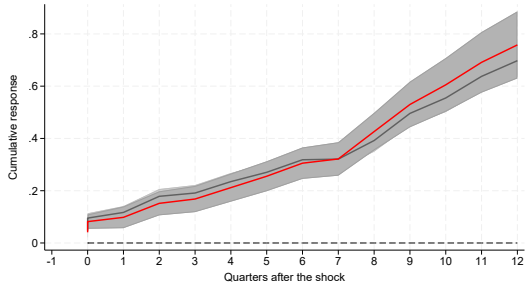
Green skills in digital occupations



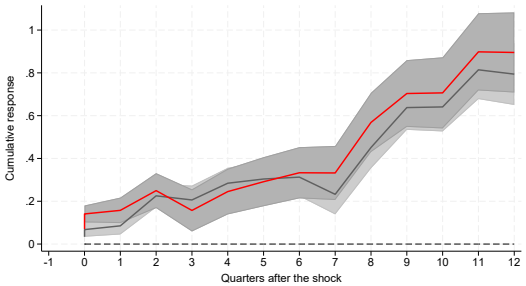
(a) Total Vacancies



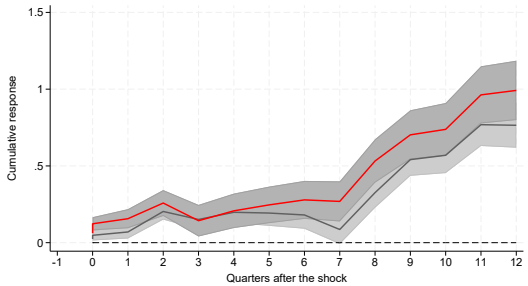
(b) Brown Vacancies



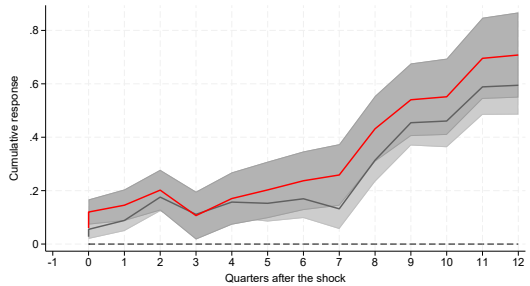
(c) Green Vacancies



(a) Total Green Skills per Vacancy



(b) Total Green Skills (share of Total Skills)



(c) Green Skill Variety

red line: digital occupations, black line: non digital occupations

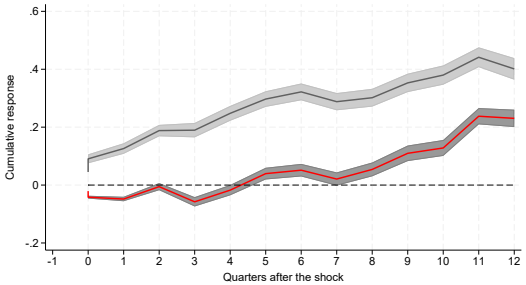
Results on vacancies - main takeaways

- CCPs have a clear greening effect on vacancies: the number of green vacancies rise, green postings also require a higher intensity of green skills, and green skills account for a larger share of all skills demanded.
- CCPs simultaneously induce firms to post more brown vacancies: adjustment to climate policies involves technological and organisational changes that raise demand for new, complementary skills not explicitly classified as "green."
- These results are general and not differentiated by occupation type (green vs brown occupations)
- Taken with the results on macro variables, CCP policies have a slightly negative overall effect on employment, while generating a reallocation within the labour market, shifting the demand across occupations and modifying their required skill content.
- Evidence of twin transition. Total number of digital skills per vacancy and the total digital skills as a share of total skills increase following a CCP shock.

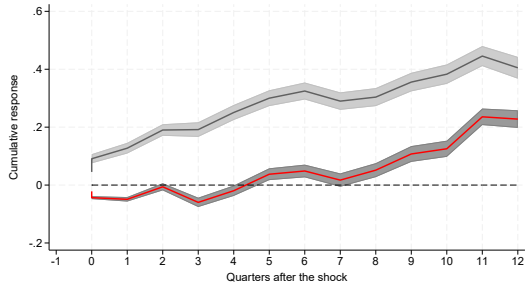
Results on vacancies: skill bias

- Share of green vacancies, total number of green skills, variety of green skills increase more in low-skill occupations than in high-skill ones.
- Green policies have a transformative effect on labour demand across the economy, with particularly strong implications for occupations typically considered less exposed to the green transition.

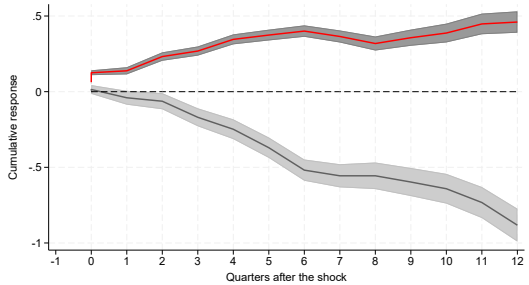
Skill bias



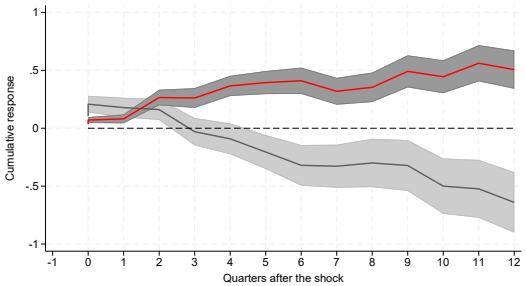
(a) Total Vacancies



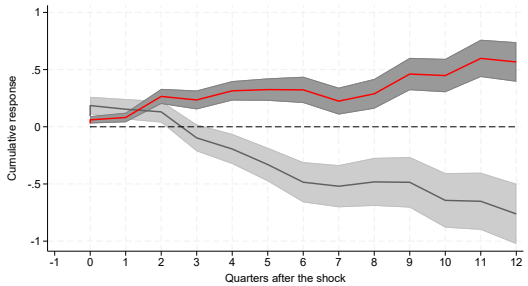
(b) Brown Vacancies



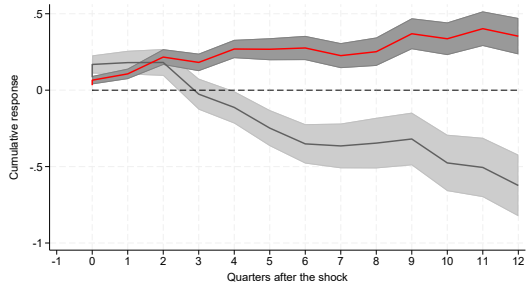
(c) Green Vacancies



(a) Total Green Skills per Vacancy



(b) Total Green Skills (share of Total Skills)



(c) Green Skill Variety

Figure: Black line: high-skill occupations, red line low-skill occupations

Conclusions

- We provide empirical evidence on the effects of climate change policies on labour market dynamics across Italian regions between 2013 and 2019.
- The overall employment response to CCP shocks is contractionary. However, both brown and green vacancies increase following these shocks, indicating that climate policies induce a substantial restructuring of labour demand that goes well beyond a simple reallocation of employment from brown to green occupations.
- We find that the demand for green skills rises markedly within traditionally brown occupations.
- We show that CCPs raise vacancy postings that require digital skills.
- Our results call for a reinterpretation of the skill-biased effects of CCPs. While brown vacancies increase predominantly in low-skill occupations, green vacancies respond more strongly in high-skill occupations, pointing to heterogeneous adjustment patterns across the skill distribution.


Bachmann, R., Baqaee, D., Bayer, C., Kuhn, M., Löschel, A., Moll, B., Peichl, A., Pittel, K., Schularick, M., 2022.
What if germany is cut off from russian energy?
VoxEU.org .


Baqaee, D., Farhi, E., 2022.
Supply and demand in disaggregated keynesian economies with an application to the covid-19 crisis.
American Economic Review 112, 1397–1436.


Baqaee, D.R., Farhi, E., 2019.
The macroeconomic impact of microeconomic shocks: Beyond hulten's theorem.
Econometrica 87, 1155–1203.


Bernard, J.T., Kichian, M., 2021.
The impact of a revenue-neutral carbon tax on gdp dynamics: The case of british columbia.
The Energy Journal 42.


Berthold, B., Cesa-Bianchi, A., Di Pace, F., Haberis, A., 2023.
The Heterogeneous Effects of Carbon Pricing: Macro and Micro Evidence.

Technical Report. London School of Economics and Political Science.


Bettarelli, L., Furceri, D., Mazzola, F., Pizzuto, P., Yarveisi, K., 2024.
The regional employment effects of climate change policies.
Mimeo.


Causa, O., Nguyen, M., Soldani, E., 2024.
Lost in the Green Transition? Measurement and Stylized Facts.
Working Paper 1796. OECD Economics Department. Paris.


Chafwehé, B., Colciago, A., Priftis, R., 2024.
Reallocation, productivity, and monetary policy in an energy crisis.
Available at SSRN 4814193 .


Dept., I.M.F.R., 2022.
World Economic Outlook, April 2022: War Sets Back the Global Recovery.

International Monetary Fund, USA.
URL: https://www.elibrary.imf.org/view/book/9781616359423/9781616359423.xml, doi:10.5089/9781616359423.081.


Känzig, D.R., 2023.
The Unequal Economic Consequences of Carbon Pricing.

Working Paper w31221. National Bureau of Economic Research.


Metcalf, G.E., 2019.
On the economics of a carbon tax for the united states.
Brookings Papers on Economic Activity 2019, 405–484.


Metcalf, G.E., Stock, J.H., 2020a.
The Macroeconomic Impact of Europe's Carbon Taxes.
Working Paper. National Bureau of Economic Research (NBER).


Metcalf, G.E., Stock, J.H., 2020b.
Measuring the macroeconomic impact of carbon taxes.
AEA Papers and Proceedings 110, 101–106.


Saussay, A., Sato, M., Vona, F., O'Kane, L., 2022.
Who's Fit for the Low Carbon Transition? Emerging Skills and Wage Gaps in Job Vacancy Data.
Working Paper 406. Centre for Climate Change Economics and Policy. Online.


Vona, F., Marin, G., Consoli, D., Popp, D., 2018.
Environmental regulation and green skills: An empirical exploration.

Journal of the Association of Environmental and Resource Economists 5, 713–753.
doi:10.1086/698859.