

How Climate Investments Reshape Green Skill Demand in Europe¹

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Abstract

This paper estimates the causal impact of European climate action investments on labour market dynamics, with a particular focus on the emergence and diffusion of green skills. Using more than 250 million online job advertisements from the Web Intelligence Hub–Online Job Advertisement (WIH-OJA) database across European regions between 2018 and 2024, we construct two measures of green skill demand capturing the intensity of green skill requirements within vacancies and their pervasiveness across postings. We link regional labour demand to climate-related expenditures financed through EU Cohesion Policy during the 2014–2020 programming period and address endogeneity in fund allocation using a shift-share instrumental variable strategy based on national mitigation investment shocks and regional exposure shares. Our results show that higher regional exposure to climate action funding significantly increases both the intensity and diffusion of green skill requirements in online vacancies. These findings indicate that early, place-based public investments in climate action play an important role in shaping firms’ skill needs and accelerating the incorporation of green competencies into hiring practices. The paper contributes to the growing literature on the labour market effects of environmental policy by providing direct evidence on skill demand, and offers relevant insights for policymakers, education systems, and firms seeking to support workforce preparation for the green transition.

Keywords:

¹PRELIMINARY DRAFT. PLEASE DO NOT QUOTE OR CIRCULATE.

1. Introduction

The purpose of this paper is to estimate the causal impact of investments in European climate action investments on labour market dynamics, with a particular focus on the emergence and diffusion of green skills and using data from online job advertisements (OJAs) in Europe. Starting from 2014, the European Commission introduced a new ‘climate mainstreaming’ approach, driven by the urgent need to address climate change, environmental degradation, and sustainability. Later, in 2019, the European Commission presented the European Green Deal, which commits to climate neutrality by 2050, with the aim of transforming the EU into a modern, resource efficient and competitive economy².

As these actions have been inducing a profound transformation in all sectors of the European economy³. Understanding how this transition impacts the labour markets is critical, particularly in terms of the skills required to support new green technologies and sustainable practices. Through the recent ‘Council recommendation on learning for the green transition and sustainable development’ of 2022 Council recommendation, Member States have in fact committed to assess the challenges and opportunities of the green transition, with the aim of putting in place comprehensive employment and social policy.

The assessment of the impact of environmental policies on the labour market can be done using a skill-based approach, which allows for a granular analysis, focusing on how specific competencies and knowledge areas are becoming more essential in the workforce. The relevance of this approach is underscored by the growing recognition that the shift towards greener economies cannot be achieved without a workforce equipped with the appropriate skills (Cedefop, 2021, 2024).

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²European Commission on the EGD

³For a detailed assessment of the interlinkages of selected occupations with the greening of the EU economy see Cedefop Occupations Insight on Science and Engineering Technicians and on Construction workers.

In the context of the climate actions, skill intelligence, which involves systematically collecting and analyzing data on labour market trends and skill needs, helps identify which green skills are becoming more prevalent and how they are distributed across different occupations and regions.

The first studies addressing the labour market effects of environmental policy changes focus on the following aspects: employment impact (Cole and Elliott, 2007; Yamazaki, 2017), labour force participation and earnings (Isen et al., 2017), productivity (Berman and Bui, 2001), and transitional costs of sectoral reallocation (Walker, 2013).

More recently, Bowen and Kuralbayeva (2015) and Consoli et al. (2016) move a step forward in the analysis of the employment effects of environmental policies, by distinguishing between green and non-green occupations. This allows them to also detect differences in terms of skill content and human capital between the two categories of occupations, and to detect the potential resulting destruction of ‘brown jobs’, that is, those jobs mainly employed in polluting industries.

Finally, Vona et al. (2018) contribute further to the analysis of the impact of environmental policies on the skills demand by introducing a new data-driven methodology to identify skills demanded in the green economy. This enables them to analyse the demand for green skills rather than simply estimating employment shares of green jobs. In detail, by using the Occupational Information Network (O*NET) taxonomy, and comparing of the skill content of jobs, they identify two core sets of green skills for which green jobs differ from non-green jobs: engineering skills for design and production of technology, and managerial skills for setting up and monitoring environmental organizational practices.

For what concerns the data used as a proxy for environmental policies, both Vona et al. (2018) and Niggli and Rutzer (2020) employ a measure of policy stringency to assess the policy impact on the demand for different skill sets, respectively in the U.S. and European labour market.⁴

For Europe, in another study, Marin and Vona (2019) exploit energy prices to proxy for climate policies and examine the associations with work-

⁴For U.S. Vona et al. (2018) exploit the variation in regulatory stringency at the regional level due to approval of new emission standards at the federal level, while for Europe Niggli and Rutzer (2020) proxy environmental policies through the index of environmental policy stringency (EPS), which incorporates a broad range of environmental policies for 19 European countries.

force skills, assessing the effect on the relative demand of occupational groups (managers, professionals, technicians, and manual workers).

To measure environmental policies, only a few studies consider green fiscal stimuli and their potential to create new employment opportunities in the so-called green economy. For U.S., the green fiscal stimuli within the American Recovery and Reinvestment Act (ARRA) were analysed by Vona et al. (2019) and Vona et al. (2021). In the first work, the authors estimate the additional number of jobs indirectly created in the local economy by a new green job, while in the second study they assess the direct effect of green fiscal stimuli, its time profile, and the heterogeneous effects across workers, sectors, and communities.

We contribute to this literature by proposing skills intelligence tools for the analysis of the impact of European climate actions on the labour market. Monitoring skill requirements and labour market trends in the context of climate actions has traditionally been challenging due to inconsistent data quality across regions and the lack of granularity in conventional data sources (Cedefop, 2024). We exploit the Web Intelligence Hub-Online Job Advertisement (WIH-OJA) database, developed by the European Centre for the Development of Vocational Training (Cedefop) and Eurostat, which offers a data-driven method to map how the greening of economies across Europe impacts labour markets. We analyse OJAs, which provide detailed and up-to-date insights, across different occupations, sectors, and regions, into the changes into occupations demanded in the labour market. We focus on OJA data from 2018 up to the most recent available information, that is for year 2024, and combine these data with information on the expenditure for climate actions from the EU Cohesion policy dataset⁵, to measure environmental policies. Indeed, the EU Cohesion policy from 2014-2020, although predating the European Green Deal, played a pivotal role in laying the groundwork for this transition, supporting investments in sectors now central to the green economy.

To address potential endogeneity, we use a shift-share instrumental variable approach, following Borusyak et al. 2025, based on national mitigation investment shocks and regional exposure shares.

Our results show that higher regional exposure to climate action funding significantly increases both the intensity and diffusion of green skill require-

⁵EU Cohesion policy dataset

ments in online vacancies.

By analysing the impact of climate actions on the demand for green skills, we can gain insights into how early investments influenced the dynamics of the labor market and helped shape the skills sets required for a sustainable future. This information is crucial for policy makers, educational institutions and businesses as they work to ensure that the workforce is prepared to meet the demands of a green economy. This is especially the case given the largely policy-driven nature of the current green transition.

This paper is structured as follows: Section 2 presents the data sources used for the analysis, while Section 3 outlines the empirical strategy. Section 4 contains a description of the main findings and Section 5 provides concluding remarks.

2. Data

To capture the dynamics of the European climate action investments, this study integrates different primary data sources. The green labour demand is measured using the Web Intelligence Hub–Online Job Advertisement (WIH-OJA) database, developed by Cedefop and Eurostat. This dataset provides detailed and timely information on vacancies, occupations, and skills, allowing for a granular analysis of labour market demand across regions and over time. Our data cover the period from 2018 to 2024 and include 27 EU Member States plus the United Kingdom, for a total of 284 NUTS-2 regions.

Green labour demand is identified through the presence of green skills in job advertisements. Following the ESCO definition⁶, an OJA is classified as green if it contains at least one green skill listed in the ESCO/Cedefop taxonomy. The identification relies on exact string matches between job advertisements and the reference list of green skills, implying that the resulting measures represent conservative lower bounds of green content in vacancies. In the selected sample, the dataset comprises 252,647,143 OJAs and 3,977 distinct skills, of which 2,140,370 advertisements and 261 skills are classified as green.

Using these data, we construct two indicators of green skill demand at the regional level, aggregated at the NUTS-2 scale. The first indicator, referred to as *greenness*, captures the intensity of green skill requirements by measuring

⁶<https://esco.ec.europa.eu/en/about-esco/publications/publication/green-skills-and-knowledge-concepts-labelling-esco>

the proportion of green skills relative to the total number of skills mentioned in job advertisements. The second indicator, *green pervasiveness*, captures the diffusion of green requirements across vacancies by measuring the share of job advertisements that include at least one green skill. Both indicators display an upward trend over the period 2018–2024, consistent with a growing incorporation of green skills in vacancy texts across European regions⁷.

Information on climate actions is drawn from the EU Cohesion policy project data made available through the Kohesio platform⁸. Cohesion policy targets regions and cities across the European Union, to support job creation, business competitiveness, economic growth, sustainable development, and improvements to citizens’ quality of life. It is implemented through several funding instruments, including the European Regional Development Fund (ERDF), the European Social Fund (ESF), the Cohesion Fund (CF), and the Youth Employment Initiative (YEI). The project-level data provide information on expenditure, beneficiaries, and policy objectives for the 2014–2020 programming period and are aggregated at the NUTS-2 regional level, to build a measure of regional expenditure over time. Our main variable of interest is the total regional expenditure on climate actions, defined as the sum of expenditure for co-funded projects classified under the explicit policy objectives associated with a “Greener, carbon-free Europe.” The dataset allows distinguishing between projects with a single policy objective and those with multiple objectives. To better align project implementation with labour market outcomes, we assign expenditure to regions using the second year since the start of each project as the reference year.

Additional regional control variables are obtained from the European Commission’s Annual Regional Database (ARDECO)⁹, which provides harmonised time series on socio-economic and demographic characteristics at the NUTS-2 level. These variables include: Gross Domestic Product (GDP) at current market prices, greenhouse gas emissions per capita, average annual population, and total employment.

At the country level, we complement these data with statistics from Eu-

⁷Recently, ESCO provided a Green Index for occupations, using the task approach. This index differs from our indicators, as it is computed using the taxonomy of skills and the link to ESCO Occupations, while we aim at capturing real time demand. As possible next step, for an additional check, we could employ their list too for our analysis.

⁸<https://kohesio.ec.europa.eu/en/>

⁹<https://territorial.ec.europa.eu/ardecoplplorer?lng=en>

rostat on environment and energy, including environmental protection investment by general government and private investment in climate change mitigation, expressed as a share of GDP, which also plays a role in the empirical identification strategy.

The final dataset, illustrated in Figure 1, is structured as a NUTS-2 by year panel and is aligned to reflect a one-year lag between climate actions and observed labour demand outcomes. In the baseline estimation window, outcome variables derived from OJAs are observed over the period 2018–2021, while climate action expenditure and other covariates are lagged and observed over 2017–2020. This timing accounts for the delayed transmission between the implementation of climate-related projects and adjustments in firms’ skill requirements as reflected in vacancy postings.

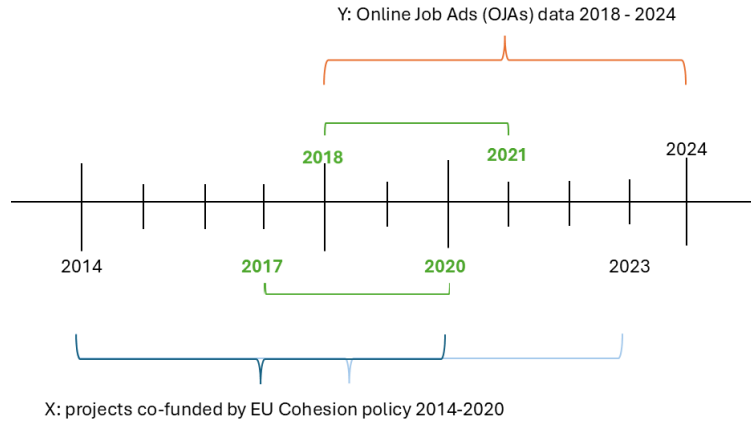


Figure 1: Structure of the final dataset and timing of variables

Descriptive evidence

Before turning to the empirical analysis, the figures below offer some insights on the distribution of OJAs and the evolution of green skill indicators in the sample.

From Figure 2, one can notice that the total number of OJAs varies substantially across countries, reflecting differences in labour market size, digital recruitment practices, and data coverage. Larger and more industrialised

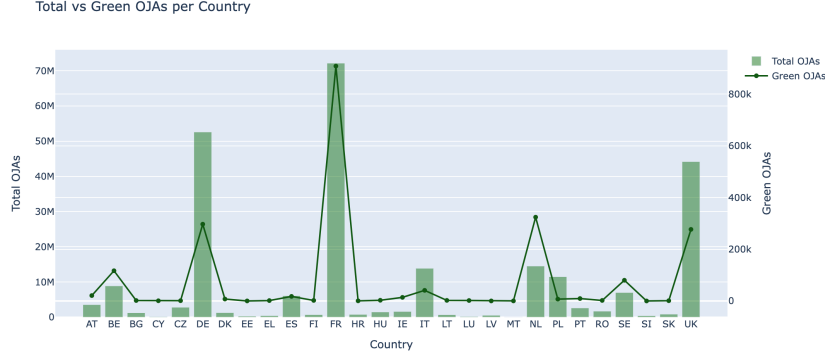


Figure 2: Total and green online job advertisements (OJAs) by country

countries, such as Germany, France, and the United Kingdom, account for a sizeable share of total postings, while smaller Member States are represented by fewer observations. Despite this heterogeneity, green job advertisements are observed in all countries, indicating that the demand for green skills is widespread across European labour markets.

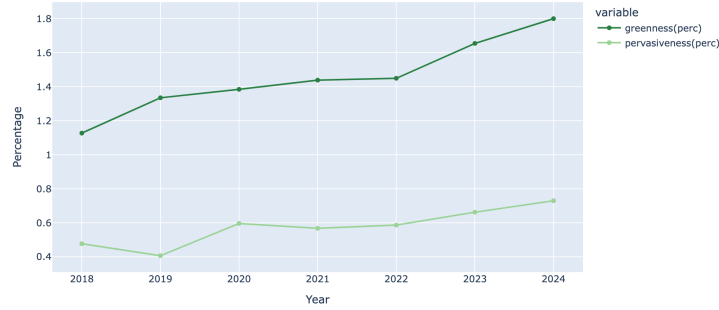


Figure 3: Evolution of average values of greenness and green pervasiveness over time.

From Figure 3, it emerges that both greenness and green pervasiveness indicators display a clear upward trend over time. Between 2018 and 2024, the average share of green skills relative to total skills mentioned in job advertisements (*greenness* indicator), increases steadily, suggesting a growing intensity of green skill requirements within vacancies. Over the same period, the proportion of job advertisements containing at least one green skill (*green pervasiveness* indicator) also rises, indicating that green requirements are becoming more pervasive across occupations and sectors rather than remaining confined to a narrow set of specialised roles. While levels and growth

rates differ across regions, these patterns are consistent with a broad diffusion of green skills in labour demand and provide descriptive support for the hypothesis that the green transition is increasingly reflected in employers' hiring needs.

3. Empirical Strategy

Estimating the effect of climate-related expenditure on green skill demand is complicated by potential endogeneity in the allocation of Cohesion policy funds. Regions with stronger pre-existing green transitions, higher institutional capacity, or different economic structures may both attract more climate spending and experience higher growth in green skill demand. To address this concern, we implement a shift-share instrumental variable approach.

Following Borusyak et al. (2025), our shift-share instrument decomposes variation in regional climate-action expenditure into a national-level shift and a region-specific exposure share. Let i index regions, c countries, and t years. The shift-share component is defined as:

$$SSI_{ict} = s_i \cdot g_{ct}, \quad (1)$$

where g_{ct} is a country-level shock capturing changes in national investment in climate change mitigation, and s_i is a region-specific exposure share reflecting how strongly a region is exposed to climate-action expenditure relative to the national total.

We estimate the following reduced-form specification:

$$Y_{ict} = \lambda_c + \phi_t + \beta SSI_{ic,t-1} + \eta_1 X_{i,t-1} + \eta_2 Z_{c,t-1} + \varepsilon_{ict}, \quad (2)$$

where Y_{ict} denotes either greenness or green pervasiveness, λ_c are country fixed effects, and ϕ_t are year fixed effects. The vector $X_{i,t-1}$ includes regional controls (GDP, greenhouse gas emissions per capita, population, and employment), while $Z_{c,t-1}$ includes a country-level control for environmental protection investment. The coefficient of interest, β , captures the effect of exogenous variation in regional exposure to national mitigation-investment shocks on green skill demand.

The identifying variation arises from the interaction between a common national shock and heterogeneous regional exposure. The shift g_{ct} captures changes in a country's overall commitment to climate change mitigation and

is common to all regions within a country. The share s_i reflects persistent differences in how climate-action funds are distributed across regions and therefore determines the intensity with which national shifts translate into regional expenditure.

This approach is well suited to our setting because individual regions are unlikely to influence national mitigation investment, and because national investment affects regional outcomes only through regions' differential exposure to climate-action funding. Under these conditions, the instrument is plausibly exogenous and satisfies the exclusion restriction.

To account for delayed adjustment between policy implementation and hiring decisions, we lag the shift-share instrument by one year. Outcomes derived from OJAs are observed in year t , while climate-action expenditure and covariates are measured in $t - 1$.

4. Results

The estimates indicate a positive and robust relationship between lagged shift-share exposure and both measures of green skill demand. For *greenness* (Table 1), the coefficient on the shift-share term is positive and statistically significant at the 1% level across all specifications. Importantly, the estimated magnitude is highly stable as additional regional and country-level controls are introduced, including GDP, greenhouse gas emissions per capita, population, employment, and national environmental protection investment. This stability suggests that the relationship is not driven by observable differences in economic scale, emissions intensity, or overall labour market size, but instead reflects differential exposure to climate-action funding.

For *green pervasiveness* (Table 2), the shift-share coefficient is also positive and statistically significant at conventional levels across specifications. Although the estimates are less precise than for *greenness*, the pattern is consistent with climate-related expenditure increasing not only the intensity of green skill content within vacancies, but also the breadth of vacancies that require at least one green skill. In other words, climate-action funding is associated with a wider diffusion of green requirements across jobs, rather than merely a deepening of green content within a narrow subset of occupations.

Overall, conditional on national investment in climate change mitigation, higher regional expenditure on climate actions is associated with greater demand for green skills in online vacancies. These findings are consistent with the view that EU-funded climate actions shape labour demand through

Greenness	(1)	(2)	(3)	(4)	(5)	(6)
Shift-share $t-1$	0.234*** (4.21)	0.231*** (4.17)	0.228*** (4.04)	0.229*** (4.08)	0.230*** (4.08)	0.229*** (4.07)
Country dummies	✓	✓	✓	✓	✓	✓
Year dummies	✓	✓	✓	✓	✓	✓
GDP		✓	✓	✓	✓	✓
GHG emissions per capita			✓	✓	✓	✓
Average annual population				✓	✓	✓
Total Employment					✓	✓
Env. prot. inv. (nat.)						✓
Obs.	700	700	700	700	700	700

*Note: Reported is only the coefficient of the shift-share variable. t statistics in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.*

Table 1: Shift-share reduced-form estimates for greenness.

investment-induced technological change, adoption of cleaner processes, and complementary organisational adjustments that require new or adapted skill sets.

5. Conclusion

This paper provides evidence that European climate actions funded through EU Cohesion policy contribute to the emergence and demand for green skills in regional labour markets. Using OJA-based measures of skill demand and a shift-share identification strategy that leverages national mitigation investment shocks and regional exposure shares, we find that higher regional exposure to climate action funding significantly increases both the intensity and diffusion of green skill requirements in online vacancies. These findings indicate that early, place-based public investments in climate action play an important role in shaping firms' skill needs and accelerating the incorporation of green competencies into hiring practices.

Future work can extend the time dimension, including further lags of expenditure on climate actions and investments in climate change mitigation to build the shift-share variable. In particular, further lagged values of investments in climate change mitigation, as percentage of GDP, could be used to construct the shift variable, so that the impact of past national expenditures is negligible, making the exclusion restriction even more plausible. With regard to the temporal dimension, additional robustness checks can be

Green pervasiveness	(1)	(2)	(3)	(4)	(5)	(6)
Shift-share $t-1$	0.262* (1.76)	0.262* (1.75)	0.261* (1.74)	0.260* (1.74)	0.260* (1.73)	0.264* (1.74)
Country dummies	✓	✓	✓	✓	✓	✓
Year dummies	✓	✓	✓	✓	✓	✓
GDP		✓	✓	✓	✓	✓
GHG emissions per capita			✓	✓	✓	✓
Average annual population				✓	✓	✓
Total Employment					✓	✓
Env. prot. inv. (nat.)						✓
Obs.	700	700	700	700	700	700

*Note: Reported is only the coefficient of the shift-share variable. t statistics in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.*

Table 2: Shift-share reduced-form estimates for green pervasiveness.

conducted to assess the potential presence of pre-trend effects, which may indicate the influence of unobserved factors that are simultaneously correlated with both the allocation of funds and the outcome variables.

In terms of additional information, regional indexes such as the index of readiness for the green transition (Maucorps et al. (2023)) or the regional competitiveness index, or country level information, such as the green growth index measuring country performance in achieving sustainability targets, or the amounts of EU funds received in the past, could also be incorporated in the analysis for further checks.

The paper contributes to the growing literature on the labour market effects of environmental policy by providing direct evidence on skill demand, and offers relevant insights for policymakers, education systems, and firms seeking to support workforce preparation for the green transition.

Appendix A.

This appendix discusses potential limitations associated with the use of online job advertisement (OJA) data to measure labour demand, drawing on recent evidence from Cedefop and OECD studies.

A comprehensive assessment of the representativeness of OJA data across EU Member States is provided by Napierala et al. (2022), who compare online vacancies with traditional labour market sources such as the Labour Force Survey (LFS) and the Job Vacancies Survey (JVS). Their analysis highlights the presence of coverage biases in OJA data along sectoral, occupational, and geographic dimensions. In particular, high-skilled occupations and more industrialised regions tend to be overrepresented in online postings, while certain occupations and regions, especially in smaller Member States, are underrepresented. These discrepancies partly reflect differences in labour market size, digital recruitment practices, and employers' reliance on online channels.

At the same time, the study documents a growing tendency among employers to use online job advertisements for a broader range of positions, including non-managerial and lower-skilled roles. This trend suggests an increasing acceptance of OJAs as a recruitment tool and points to a gradual improvement in their coverage over time. Importantly, the authors also note that traditional sources such as the LFS and JVS are themselves subject to limitations, including varying response rates and methodological differences across Member States, which complicate cross-country comparisons and affect data reliability.

Additional evidence on the representativeness of web-scraped vacancy data is provided by OECD studies based on Lightcast data for Australia, Canada, the United Kingdom, and the United States between 2015 and 2022 – Tsvetkova et al. (2024), as well as for selected European countries between 2019 and 2022 – Vermeulen and Amaros (2024). These studies compare online job postings with administrative and public employment service (PES) data and find that, while online vacancies capture overall labour market trends reasonably well, substantial heterogeneity exists across countries, regions, and sectors. For Europe, the evidence shows a marked increase in online postings between 2018 and 2019, reflecting improvements in data collection methods, but also reveals significant regional variation in the ratio of online vacancies to national sources. Countries such as Austria and Germany exhibit fluctuations between undercounting and overcounting, whereas

Sweden and Belgium consistently report higher vacancy numbers in online data.

The OECD analyses further indicate that online job postings tend to better represent urban areas than rural ones and that discrepancies can arise from both occupational and geographical misclassification. For example, job titles associated with multiple occupational groups are more likely to be incorrectly classified by automated algorithms, and job locations may be inaccurately recorded when employers list a nearby large city instead of the actual workplace location. While Lightcast data can complement traditional labour market sources such as Eurostat statistics and PES data, the correlation with administrative sources can be weak in some regions, suggesting caution in relying exclusively on online postings.

Overall, these studies underscore the importance of accounting for the limitations of OJA data when using them for empirical analysis. Researchers should interpret OJA-based indicators as informative proxies for labour demand rather than exhaustive measures, and should implement appropriate data checks tailored to the specific research question and context. In the present study, these considerations motivate a focus on relative changes and within-region variation over time, rather than on absolute levels of labour demand.

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