

The green economic transformation needed to achieve net zero emissions will also require changes in employment. This chapter examines the labor market implications of this transition, using a mix of empirical and model-based analyses. Looking at a sample of largely advanced economies, the empirical analysis indicates that both greener and more polluting jobs are concentrated among small subsets of workers. Individual workers face tough challenges in moving to greener jobs from more pollution-intensive jobs, complicating labor reallocation. Higher skills make job transitions easier, highlighting the potential importance of training. Stronger environmental policies help green the labor market and appear more effective when reallocation incentives are not blunted. Finally, a policy package incorporating a green infrastructure push, phased-in carbon prices, and targeted training and an earned income tax credit to provide income support and incentivize labor supply could put an economy on a path to net zero emissions by 2050, with an inclusive transition. Model simulations for a representative advanced economy suggest that about 1 percent of employment would shift toward greener activities over a 10-year period. By contrast, for a representative emerging market economy, about 2.5 percent of employment would shift, reflecting differences in workforce skills and greater reliance on higher-emissions-intensive production. Delays in policy actions will require sharper labor market adjustments to achieve net zero emissions.

Introduction

The COVID-19 pandemic has generated enormous disruptions and dislocations in economies and labor markets.¹ In shaping the recovery from the pandemic,

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¹See Chapters 1 and 3 of the April 2021 *World Economic Outlook* for evidence and discussion of the impacts of the COVID-19 pandemic and associated recession on economic activity and labor markets.

policies can be primed to address key challenges and create more productive, resilient, and sustainable economies (see Georgieva and Shah 2020 for a discussion). Of all the urgent issues, tackling human-induced climate change is among the most pressing.

Mitigating global warming will require substantial reductions in greenhouse gas (GHG) emissions. The objective of limiting the average global temperature increase to well below 2°C and preferably no more than 1.5°C above preindustrial levels was endorsed by policymakers around the world in the 2015 Paris Agreement (see IPCC 2015, 2018; COP 2015). For this goal to be met, net emissions (the difference between GHG emissions produced and GHG removed from the atmosphere) must decline to zero by 2050.

The green transformation of production structures needed to achieve net zero emissions—with large changes expected in capital infrastructure for greener energy and products—will also entail a transformation of the labor market, changing the allocation of workers across occupations and sectors. Previous *World Economic Outlook* (WEO) analysis has found the policy package required to achieve net zero emissions by 2050 would lead to about 2 percent of the global workforce changing the sector in which they work over the next 30 years, with workers moving from polluting, higher-emissions sectors to those that are cleaner and generate lower emissions.²

Aiming to better understand the employment changes required for the green transformation and possible obstacles, this chapter investigates the environmental properties of jobs, how easily workers are able to move into greener—that is, more sustainable, less polluting, and emissions-lowering—employment, and how policies may affect the greening of the labor market. It makes two key contributions: (1) a new cross-country, harmonized set of indicators of the environmental properties of jobs, built in part on earlier single-country studies; and (2) a new model-based

²See Chapter 3 of the October 2020 WEO. The package involved a combination of international carbon pricing, a green investment push, and targeted cash transfers to groups at higher risk of being adversely affected by mitigation measures.

analysis of labor reallocation in the green transition with an expanded set of policy instruments. The chapter examines the environmental properties of jobs through two lenses: *what workers do* (their occupations) and *where they work* (the sectors in which they are employed). It takes the perspective that the environmental properties of jobs are multidimensional, involving the extent to which workers undertake tasks that improve environmental sustainability (*green intensity*) and the degree to which their work involves activities exacerbating pollution (*pollution intensity*), as well as the level of emissions generated per worker (*emissions intensity*). Among the many occupations classified, an example of a more green-intensive occupation is an electrotechnology engineer, while a more pollution-intensive occupation is a paper mill machine operator. An example of a typically more emissions-intensive sector is utilities, including electricity and gas.³

Employment changes have already played an important role in improving sustainability, based on the recent experience in a sample of advanced economies. Between 2005 and 2015, average total carbon emissions per worker (the measure of emissions intensity) in the sample declined by 27 percent (Figure 3.1).⁴ The bulk of that decrease was attributable to improved sectoral efficiency, including a mix of emission-lowering, within-sector labor reallocation and changes in capital and technology. However, almost a quarter of the decline was related to workers' moving from higher- to lower-emissions-intensive sectors. Therefore, although sectoral labor reallocation has not been the primary contributor to emissions reductions, it has played a role, alongside within-sector labor reallocation.

Drawing both on empirical and model-based analyses, the chapter asks:

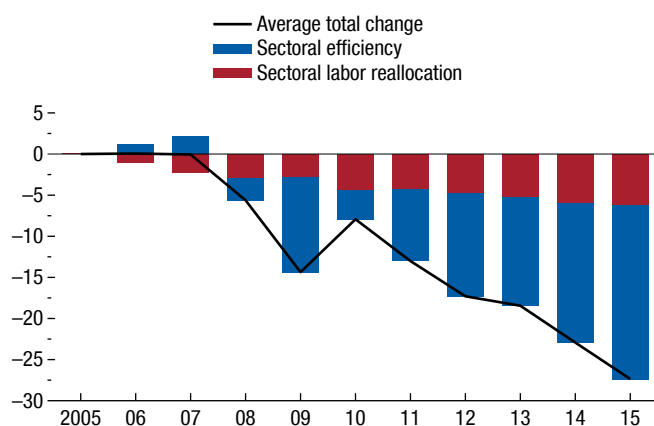
- **How green is the labor market?** What are the environmental properties of jobs, and how do those

³The specific measurement of these three intensity indicators is described in the next section.

⁴Carbon (carbon dioxide or CO₂) emissions are more readily available and comparable across sectors and economies over a longer period of time than the broader category of GHG emissions. Moreover, carbon emissions account for the largest share of global GHG emissions, at three-fourths of the total (US EPA 2022). Carbon emissions are the emission measure used in this chapter. Total carbon emissions incorporate both direct and indirect carbon emissions. Indirect emissions are counted as the carbon emissions embodied in intermediate inputs used in production (see the IMF Climate Change Indicators Dashboard and Online Annex 3.1 for further details).

Figure 3.1. Evolution of Average Carbon Emissions Intensity
(Percentage point change in CO₂ emissions per worker relative to 2005)

Average emissions per worker decreased between 2005 and 2015 for the countries in the sample, with labor reallocation playing a role.



Sources: IMF, Climate Change Indicators Dashboard; International Labour Organization; Organisation for Economic Co-operation and Development; and IMF staff calculations.

Note: The figure shows the percentage point change in the cross-country average carbon emissions intensity relative to 2005. See Online Annex 3.1 for details on the underlying country sample and data sources.

properties vary across economies and sectors? How are they associated with demographic characteristics (such as educational attainment and urbanicity) and earnings?

- **How easily do workers transition into greener jobs?** What are the characteristics of workers (including their employment history and education or skills) who more readily move into these jobs? Do workers have the skills needed for greener employment?
- **How do environmental policies affect the reallocation of workers into greener jobs?** Can policies help make the labor market greener? Is the effectiveness of such policies affected by an economy's labor market policies and structural features? What are the consequences for overall employment and income distribution?

Importantly, the empirical analysis in this chapter takes the prevailing state of technology as given, investigating how labor allocation may respond to policy changes. As suggested by Figure 3.1, technology adoption and innovation—a focus of Chapter 3 of the October 2020 WEO—also has a critical role to play in the green economic transformation. The model-based analysis incorporates technological change (potentially

spurred by policy), allowing its contribution to the green transition in the labor market to be gauged. Data constraints mean that the empirical analysis uses a limited sample of 34 countries (mainly the United States and advanced economies in Europe) covering 2005–19. To assess how an economy’s development level may affect employment in the green transition, illustrative scenarios in the model-based analysis are calibrated to reflect initial conditions for representative advanced and emerging market economies. These are the chapter’s main findings:

- *More green- and pollution-intensive jobs appear concentrated among a subset of the workforce, leading to low average green and pollution intensities of jobs.* Green and pollution intensities quantify the share of activities in a given occupation that improve or degrade environmental sustainability, respectively. The lion’s share of jobs is neutral in respect to these two properties, with zero green and pollution intensity scores. There is a wide dispersion of environmental properties of jobs across and within sectors, suggesting that scope exists for reallocation both across and within sectors to help green the labor market. Higher-skilled and urban workers tend to have more green-intensive occupations than lower-skilled and rural workers. Moreover, even with skills and other individual-level characteristics controlled for, green-intensive occupations exhibit an average earnings premium of almost 7 percent compared with pollution-intensive occupations.
- *Environmental properties of jobs tend to be sticky in transitions, pointing to difficulties for workers in more pollution-intensive or neutral jobs in moving up the green ladder.* The probability that a worker will transition into greener work from pollution-intensive work when changing jobs is comparatively low, though not statistically significantly different than the probability of making that transition from a neutral job, which reflects how tough it is to change occupations. Higher skills make it easier to transition into more green-intensive work, suggesting that further human capital accumulation could help boost workers’ prospects for greener employment.
- *Environmental policies tend to be more effective when labor market policies and structural features do not inhibit incentives for reallocation.* More stringent environmental policies are associated with employment that is more green- and less pollution-intensive, making for a greener labor market. Labor market policies and structural features

may need realignment to avoid diminishing the impetus for labor reallocation from greener policies. In particular, with a strong recovery from the COVID-19 pandemic recession underway, it will be important to reduce job retention support measures to help provide incentives for reallocation (in line with country-specific circumstances).

- *With the appropriate policy package, an economy can get on the path to net zero emissions by 2050, while improving the average economic conditions of lower-skilled workers.* Similar to earlier IMF advice, the package should include a green infrastructure push and a gradual phase-in of carbon taxes. It should also include a training program—targeted toward lower-skilled workers to boost their productivity in lower-emissions-intensive work—and an earned income tax credit, providing income support and incentivizing labor supply. Both would help encourage labor reallocation while ameliorating inequality.
- *In an illustration with a representative advanced (emerging market) economy, about 1 (2.5) percent of employment will shift from higher- to lower-emissions-intensive work over the next 10 years to get on the net zero emissions path.* The shift is larger for emerging markets, reflecting their larger initial employment shares in higher-emissions-intensive sectors. For the group of advanced economies, the size of these labor shifts is smaller than the almost 4 percent of employment per decade shift from industry to services sector work since the mid-1980s. Finally, while the overall long-term employment effects are small, they can be slightly positive or negative depending on the magnitude of adjustment needed and the policy package used.

Taken together, the results indicate that the employment changes required by the green transformation are moderate in a historical, macroeconomic context. This reflects in part the small initial shares of employment that are more pollution-intensive and in higher-emissions-intensive sectors.⁵ Modest technological and productivity improvements—spurred by policies in the model scenarios—are essential to maintain or grow employment while lowering emissions.

⁵For example, only about 1 percent of employment is in the utilities sector (energy and water/sewage; the sector with the highest average emission intensity) on average for a sample of advanced economies (Online Annex Figure 3.2.1 sample). See the next section for further discussion.

However, the transition may entail considerable challenges for individuals. Although more green- and pollution-intensive jobs are on average concentrated among a smaller subset of workers, the extent of labor reallocation required will vary according to country and within-country regional characteristics (see Box 3.1 for evidence on the geographic distribution of the environmental properties of jobs in the United States). Areas that rely more heavily on higher-emissions-intensive production will have a larger reallocation need and a potentially tougher transition.⁶

The analysis demonstrates that it is difficult for any given individual to switch to a greener occupation, which should temper any inference that the transition will be easy. This is especially the case for lower-skilled workers, which highlights the importance of including well-designed training programs in the policy package.⁷ More broadly, occupational switches are not easy.

Some important caveats to these analyses need stating. First, because of data limitations, the green and pollution intensities assigned to occupations in the empirical analysis are invariant over time. However, employment could become greener without reallocation across occupations if technological changes increased green intensities and decreased pollution intensities by occupation. Second, the empirical results are derived using a sample composed largely of advanced economies, which makes the results less applicable to the typical emerging market or developing economy, in particular, one with a large share of informal employment. Third, even when the analysis of the empirical effects of policies takes place at the individual level, omitted variables may still be a concern, which suggests that the empirical policy-related results should be interpreted as associational rather than causal. More generally, the empirical analysis relies upon historical patterns in the data to assess policy effects, which may not be representative of the size and mix of policy changes needed to achieve net zero emissions.

⁶For example, see Online Annex 1.6 to the October 2019 *Fiscal Monitor* for a study of regions that are heavily dependent on coal.

⁷In a meta-analysis, Card, Kluve, and Weber (2018) find that training programs have typically positive medium-term impacts on participants' prospects. Specific program design elements, which must be calibrated to the country and regional context, also affect cost and success. See Levy Yeyati, Montané, and Sartorio (2019) for recent findings. Although there has been particular interest in developing skills for a greener economy (OECD and Cedefop 2014), there are no comprehensive evaluation studies on such specific training aspects.

With the flexibility of its calibration and incorporation of technological change, the model-based analysis attempts to address these shortcomings of the empirical analysis. However, it too comes with limitations. If there were a mismatch in the timing of the destruction of more pollution- and emissions-intensive jobs and the creation of greener jobs, then there could be a rise in unemployment over the near term. The model used here is one of structural transition with a labor supply decision and does not incorporate involuntary unemployment. That said, the model does account for structural changes in the skills of the workforce (improved by training), which may well help ease the adjustment over a longer period. Finally, the analysis uses a closed economy framework for simplicity and does not consider possible international spillovers from policy changes.⁸

Important factors outside the chapter's scope could complicate the transition to a greener economy. The scenario-based analysis assumes that policies are fully credible, transparently announced, and implemented in a timely manner. However, the risk is large that policy uncertainties and delays will continue—for example, as a result of political economy constraints.⁹ With these uncertainties and delays, the transition will be more challenging and potentially require even sharper adjustment. Moreover, if the policy package is only partly implemented or its implementation is poorly sequenced, the transition could exacerbate income inequality and net employment losses.

The chapter begins by defining the environmental properties of jobs and documenting their incidence and distribution. It also explores how these properties vary with worker characteristics. The chapter then turns to individual-level job transitions and how they change with the environmental properties of jobs (source or destination). In the penultimate section, the chapter analyzes how environmental policies can help green the employment landscape, how policy effectiveness may vary with labor market policies and structural features, and the content and shape of a policy package to make the green transition.

⁸See Chapter 3 of the October 2020 WEO, which takes a global perspective in its examination of activity and does incorporate the possible international spillovers from climate mitigation policies.

⁹See the October 2019 *Fiscal Monitor* for a discussion about political economy concerns related to the green economic transformation.

Environmental Properties of Jobs: Definitions and Stylized Facts

This chapter takes the perspective that the environmental properties of jobs are multidimensional, examining them through two lenses: what workers do (their occupations) and where they work (their sectors). For the first lens, the chapter constructs an occupation-level measure of the *green intensity* of a job, based on the taxonomy of tasks and occupations from Dierdorff and others (2009) and O*NET Center (2021) and similar to that in Vona and others (2018). This measure is computed by occupation as the share of green tasks in total tasks in the work. The chapter also constructs an occupation-level measure of the *pollution intensity* of a job, building on the classification of Vona and others (2018), who identify polluting occupations as those particularly predominant in high-GHG-emitting and high-polluting sectors.¹⁰

As defined, the measures of green and pollution intensity each range continuously from 0 to 100 (expressed as a percent), with higher values indicating greener or more polluting occupations, respectively. It is possible for an occupation to be neither green- nor pollution-intensive (both measures are zero). The chapter refers to these as *neutral* occupations, and they account for the bulk of jobs.

For the second lens, the chapter matches information on the sectors in which people are employed with the emissions intensity (in total tons of carbon dioxide emitted per worker) by sector and country. Higher-emissions-intensive sectors include utilities, mining, and manufacturing.¹¹

A natural question is how these environmental properties of jobs relate to each other, as they each capture a different environmental dimension of a given job. The green and pollution intensities of employment show a negative relationship to each other within the sample of employed workers, reflecting a general

property that more green-intensive occupations tend to be less polluting. More pollution-intensive jobs are positively related to jobs in more emissions-intensive sectors.¹² Taken together, these findings provide reassurance that the three environmental properties of jobs are sensibly associated with each other.

Higher Green, Pollution, and Emission Intensities Are Concentrated among a Small Subset of Workers

For the sample of economies analyzed, the average employment-weighted green intensity of occupations ranges from about 2 to 3 percent for most economies in the sample, while the average employment-weighted pollution intensity is between about 2 and 6 percent (Figure 3.2, panels 1 and 3). Many jobs have very low green and pollution intensities: most are neutral (Figure 3.2, panels 2 and 4). Despite the urgency of the climate change threat, the rise in average green intensity and fall in average pollution intensity over the past decade have been incremental.

On the other hand, the emissions intensity of employment has fallen noticeably over the same period for the economies in the sample (Figure 3.2, panel 5). As noted, this partly reflects labor reallocation from higher- to lower-emissions-intensive sectors. In fact, the average share of employment in the higher-emissions-intensive sectors of mining, manufacturing, and utilities fell from about 18 percent in 2005 to 15 percent in 2015. While the median individual-level emissions intensity for the average country within the sample stood at about eight tons of carbon dioxide per worker in 2015, there is a substantial right skew in the average employment distribution, indicating that there is only a small share of workers involved in activities generating high carbon emissions (Figure 3.2, panel 6).¹³

¹²See Online Annex 3.1 for the underlying analysis of these relationships across measures.

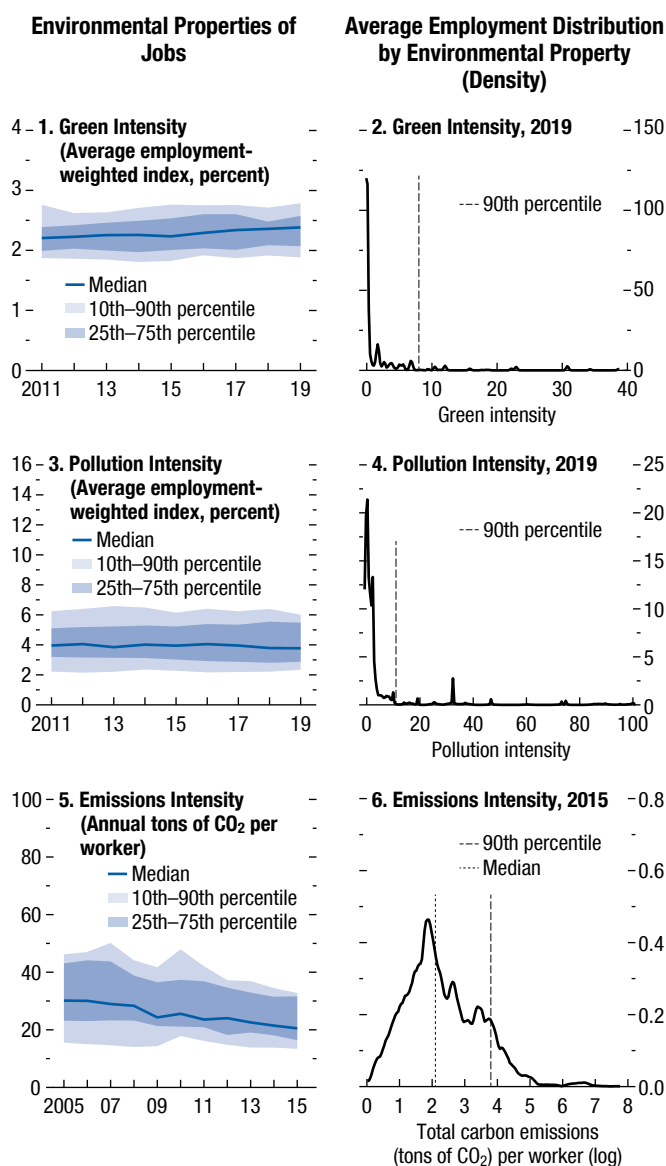
¹³Other measures or definitions could generate different conclusions. For example, a broader definition that includes jobs that could see increased demand during a green transition while not actually involving green tasks themselves and that does not distinguish between jobs that are more versus less heavily affected (a simple binary classification) could generate a larger share of employment. For example, Bowen, Kuralbayeva, and Tipoe (2018) apply such a broader definition and calculate that almost 20 percent of employment in the United States is green. See also ONEMEV (2021) for its classification of the green economy in France. It finds that about 0.5 percent of employment is green, while another 14 percent is “greening” in some way. See also IMF (2022).

¹⁰See Online Annex 3.1 for details on the construction of these indices and examples of selected occupations and their associated scores. Both green and pollution intensities take underlying inputs from the US occupational classification system, which are cross-walked to the international standard occupational classification system with employment weights. Green intensity is the average employment-weighted share of green tasks in total tasks in an international standard occupation. Pollution intensity is interpreted as the average employment-weighted share of polluting activities in an international standard occupation.

¹¹See Online Annex 3.1 for a description of the calculation of sectoral emissions intensity and the underlying emissions data.

Figure 3.2. Cross-Country Distribution and Evolution of Green- and Pollution-Intensive Occupations and Carbon Emissions per Worker

Although it has risen slowly over recent years, green intensity remains low on average, indicating further scope for greening. Pollution intensity has declined marginally, while emissions intensity has fallen about one-third, on average.



Sources: EU Labour Force Survey; IMF, Climate Change Indicators Dashboard; International Labour Organization; National Institute of Statistics and Geography (INEGI) (Mexico), National Survey of Occupation and Employment; Occupational Information Network; Organisation for Economic Co-operation and Development; Statistics South Africa, Quarterly Labour Force Survey; US Census, Current Population Survey; Vona and others (2018); and IMF staff calculations. Note: Panels 1 and 3 are computed as the share (percent) of occupational tasks in the total economy that are green-intensive and the share (percent) of occupations that are pollution-intensive, respectively, weighted by employment for each country. Panel 5 exhibits carbon emissions intensity for the average worker by country. Data are shown over the time periods for which they are available. Panels 2, 4, and 6 show the average kernel density for employment (see Silverman 1986). See Online Annex 3.1 for details on country samples.

Labor Reallocation Can Strengthen the Green Transition

The green intensity of occupations varies across sectors, with that in industrial sectors higher on average, but sectoral averages are generally low (Figure 3.3, panel 1). Industrial sectors are also typically more pollution-intensive, but with averages notably higher in a few sectors, such as mining, manufacturing, and energy production (Figure 3.3, panel 2).

There is also wide dispersion in green and pollution intensities within sectors, as shown by the whiskers in the panel. This illustrates that there can be substantial within-sector differences in how green- or pollution-intensive workers' jobs are.

For a given sector, large differences in emissions intensity can be seen across countries, reflecting wide variation in technology and efficiency across countries (Figure 3.3, panel 3). Overall, these results highlight the substantial potential to “move up the green ladder” or “down the pollution ladder” within and across sectors.

Higher-Skilled and Urban Workers Tend to Have More Green-Intensive and Less Pollution-Intensive Occupations

Further greening of the labor market is easier if workers already have the skills needed in more green-intensive jobs. Higher-skilled workers tend to be in occupations with higher green and lower pollution intensities than lower-skilled workers (Figure 3.4).¹⁴ Among other demographic characteristics, urbanicity stands out: urban workers tend to have occupations with higher green and lower pollution intensities than rural workers. At the same time, there is no statistically significant difference between the average emissions intensities of urban and rural workers.

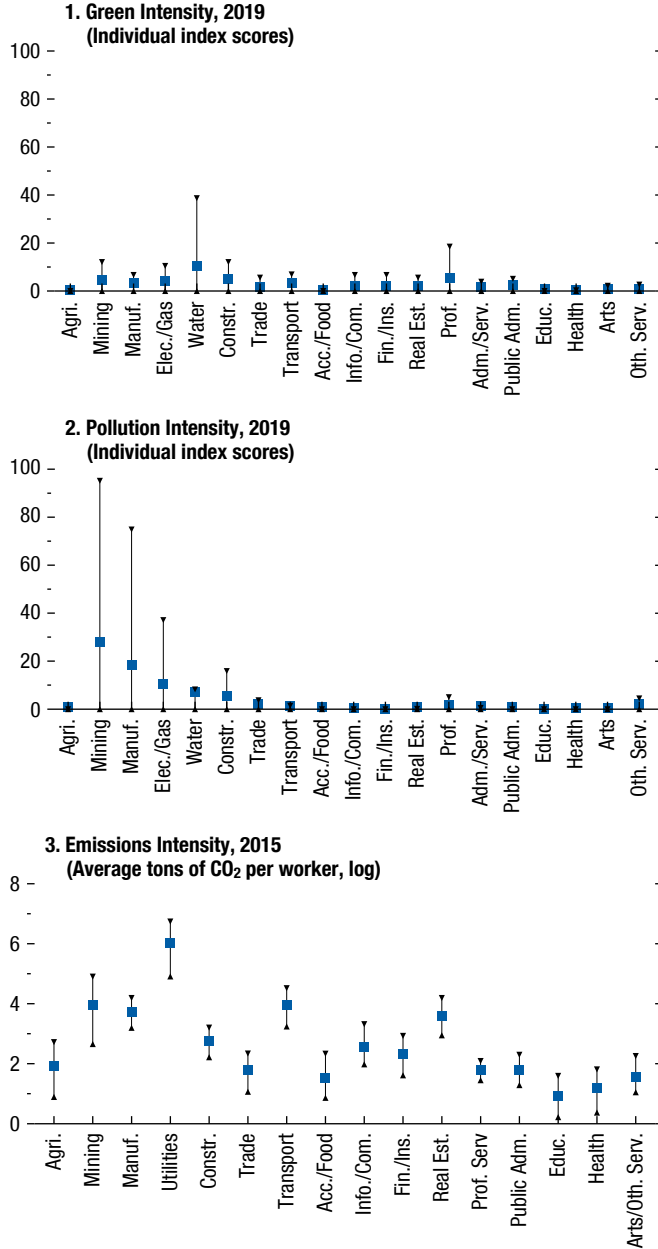
Average Green-Intensive Job Earns More Than the Average Pollution-Intensive Job

Even after an individual's skill level and other demographic characteristics are controlled for, the average green-intensive job commands earnings almost 7 percent higher than the average

¹⁴Online Annex 3.2 presents evidence that general green skills (skill categories most highly associated with green-intensive employment) are relatively evenly distributed across sectors. The wide dispersion within sectors and the similar levels across sectors suggest that further greening of the economy without massive skill changes at the macroeconomic level may be possible.

Figure 3.3. Sectoral Differences in the Distribution of Green, Pollution, and Emissions Intensities in Employment

There is substantial room to boost green intensity in economies by reallocating workers away from highly polluting occupations both within and across sectors.

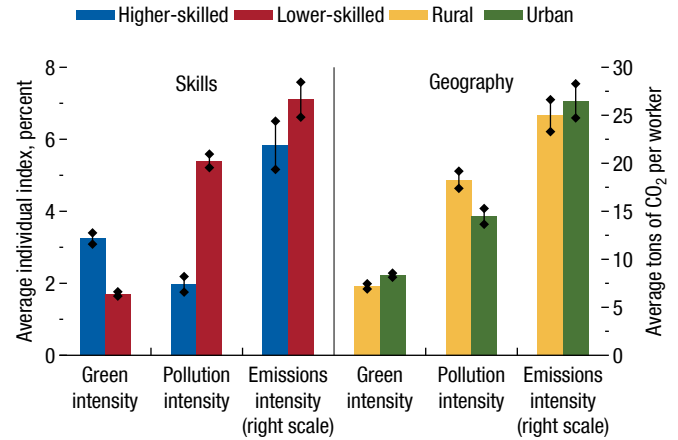


Sources: EU Labour Force Survey; International Labour Organization, ILOSTAT database; IMF, Climate Change Indicators Dashboard; National Institute of Statistics and Geography (INEGI) (Mexico), National Survey of Occupation and Employment; Occupational Information Network; Organisation for Economic Co-operation and Development; Statistics South Africa, Quarterly Labour Force Survey; US Census, Current Population Survey; Vona and others (2018); and IMF staff calculations.

Note: Squares represent the mean for the sector across individuals in the sample, while whiskers represent the 10th–90th percentile range. Sectors are classified according to International Standard Industrial Classification Revision 4. See Online Annex 3.1 for details on the country sample for the charts and definitions of the abbreviations used.

Figure 3.4. Environmental Properties of Jobs by Worker Characteristics

Higher-skilled workers' jobs are more green- and less pollution-intensive; pollution-intensive jobs are more concentrated in rural areas.



Sources: EU Labour Force Survey; IMF, Climate Change Indicators Dashboard; National Institute of Statistics and Geography (INEGI) (Mexico), National Survey of Occupation and Employment; Occupational Information Network; Organisation for Economic Co-operation and Development; Statistics South Africa, Quarterly Labour Force Survey; US Census, Current Population Survey; Vona and others (2018); and IMF staff calculations.

Note: The bars show the averages for the property over the employment-weighted sample of individuals with the characteristic indicated. Lower-skilled workers have at most secondary and nontertiary education or below, while higher-skilled workers have postsecondary or tertiary education. Whiskers depict the 90 percent confidence band around the estimates.

pollution-intensive job (Figure 3.5).¹⁵ This premium has trended slightly upward in recent years, potentially helping to provide incentives for the transition toward a greener economy.

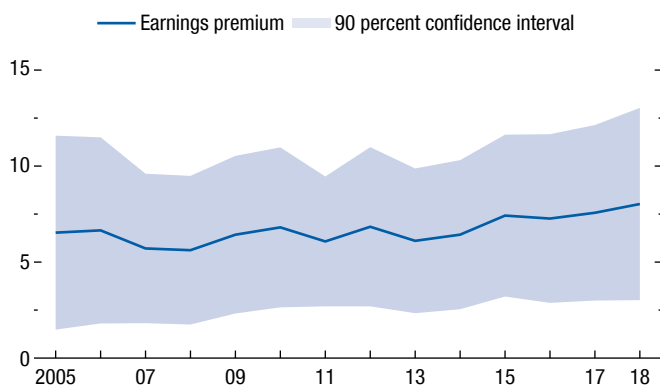
Environmental Properties of Job Transitions

This section investigates how easily workers move into greener jobs, examining individual-level job transitions. These transitions include such changes as an unemployed person's finding a job, an employed person's separating from a job, and changes in occupation or the sector in which a person works. As benchmarks, an average of about 8 percent of workers a year switch to a new job while employed or "on-the-job" for the countries in the sample used in this chapter, while about 52 percent of those who were out of work the previous year (either unemployed or not participating)

¹⁵See Online Annex 3.3 for details on the earnings premium. The findings are similar to those of Vona, Marin, and Consoli (2019) for the United States.

Figure 3.5. Earnings and the Environmental Properties of Jobs (Percent)

The average green-intensive job commands a small earnings premium relative to the average pollution-intensive job, even when skill levels are controlled for.



Sources: EU Labour Force Survey; Occupational Information Network; Organisation for Economic Co-operation and Development; US Census, Current Population Survey; Vona and others (2018); and IMF staff calculations.
 Note: See Online Annexes 3.1 and 3.3 for details on the country sample and the estimation of the earnings premium.

find new jobs in the current year (Figure 3.6, panel 1). About 6 percent of workers separate from (leave) their job each year.¹⁶

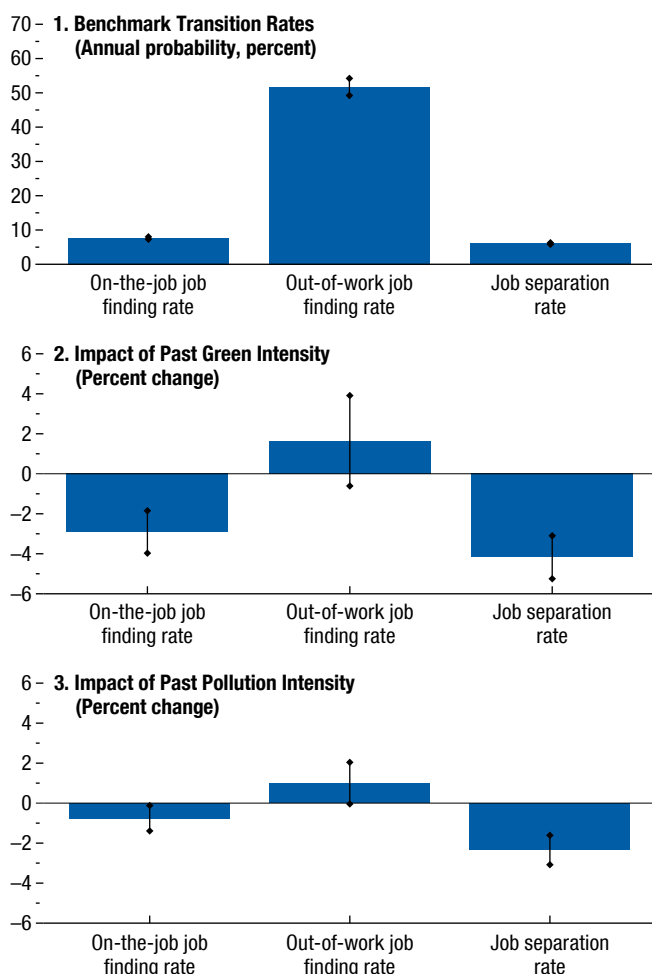
Green-Intensive Jobs Exhibit Less Churn Than Pollution-Intensive Jobs

Both green- and pollution-intensive jobs see less churning—fewer transitions—than neutral jobs. Workers with either more green- or more pollution-intensive jobs have lower on-the-job transition rates than those with neutral jobs (Figure 3.6, panels 2 and 3). Out-of-work individuals with a history of more green- or pollution-intensive employment also appear to find jobs more easily than those previously employed in neutral jobs, although this difference is not statistically significant. Finally, workers who previously held more green-intensive or more pollution-intensive jobs are also less likely to separate from their jobs than those who previously held neutral jobs. Taken together, these results suggest that workers in nonneutral jobs have greater job stability on average, with those with more green-intensive jobs the most stable.

¹⁶These rates are similar to those found in the literature. See Elsby, Hobijn, and Şahin (2013) and Hobijn and Şahin (2009), among others.

Figure 3.6. Job Transition Rates and the Environmental Properties of Past Jobs

Workers in more green- and pollution-intensive jobs enjoy greater job security on average, with more green-intensive jobs having the greatest stability.



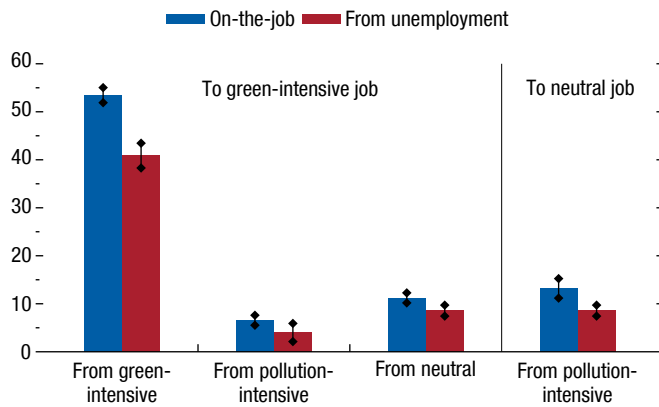
Sources: EU Statistics on Income and Living Conditions; US Census, Current Population Survey; and IMF staff calculations.
 Note: In panel 1, each bar shows the estimated average transition rates in our sample. In panels 2 and 3, each bar shows the indicated average transition rate in the sample. The whiskers depict the 90 percent confidence intervals around the estimated coefficients. The differences between more green- and pollution-intensive jobs are statistically significant for job-to-job finding and job separation rates. See Online Annexes 3.1 and 3.4 for details on the country sample and estimation.

Environmental Properties of Jobs Are Sticky, and Transitions Can Be Tough

Zooming in on transitions into more green-intensive jobs, workers already employed in such jobs are highly likely to find work of a similar nature in a transition, with finding rates from unemployment or on-the-job of 41 and 54 percent, respectively (Figure 3.7). By contrast,

Figure 3.7. Annual Probability among Job Switchers of Transitioning into a Green-Intensive or Neutral Job (Percent)

Moving from a more pollution-intensive or a neutral job to a more green-intensive job is more difficult than moving from one green-intensive job to another.



Sources: EU Statistics on Income and Living Conditions; National Institute of Statistics and Geography (INEGI) (Mexico), National Survey of Occupation and Employment; Occupational Information Network; US Census, Current Population Survey; Vona and others (2018); and IMF staff calculations.
 Note: Probabilities are calculated based on transitions across three job types among individuals switching jobs. For the discrete state transition probabilities exhibited in this figure, a job is defined to be green-intensive if its green intensity is positive and its pollution intensity is zero; likewise, a job is defined to be pollution-intensive if its pollution intensity is positive and its green intensity is zero. A job is defined to be neutral if its green and pollution intensities are both zero. Whiskers depict the 90 percent confidence band around the estimates. See Online Annexes 3.1 and 3.4 for details on the sample and estimation.

it is not as easy for workers in pollution-intensive and neutral jobs to move to more green-intensive jobs. The probability of moving from a pollution- to a green-intensive job when transitioning is between 4 and 7 percent. For workers coming from neutral jobs, the rates are slightly higher, ranging from 9 to 11 percent. Although it is somewhat easier than moving into green-intensive jobs, workers with more pollution-intensive job histories also find it difficult to move into neutral jobs, with rates around 11 percent. These results in part reflect how tough it is in general to change occupations.¹⁷

¹⁷The simple probabilities calculated here do not control for other worker characteristics. See Online Annex 3.2 for further analysis comparing job transitions across workers with differing employment histories after accounting for worker demographic characteristics, including skills. These findings show that the stickiness of the environmental properties of jobs and difficulties with job transitions are robust.

Labor Markets and Environmental Policies: Empirical and Model-Based Analyses

As discussed, the green economic transformation necessary to respond to climate change will likely mean that employment must become more green-intensive and decrease its pollution and emissions intensities. However, and as just demonstrated, the environmental properties of jobs tend to be sticky, with workers finding it easier to move into occupations with properties similar to their previous occupations.¹⁸ As it is tougher for workers with pollution-intensive or neutral job histories to move into more green-intensive work, an important question is whether policies can help increase (reduce) the share of green-(pollution-)intensive jobs in the economy and make worker reallocation easier to facilitate the green economic transformation.

To make progress in answering this question, this section first provides an empirical assessment of the relationships between a country’s environmental policy stringency and the environmental properties of workers’ employment. It then examines how a country’s labor market policies and structural features may affect these relationships. However, recognizing that these empirical estimates rely on a composite index of the environmental policy stance and are associational rather than causal, this section then uses a newly developed task-based model of the labor market to study the content and shape of a policy package that can guide the economy through the green transition. By varying the calibration, the model allows the influence of country characteristics on policy effectiveness and the transition path to be evaluated.

Empirical Estimates of the Labor Market Effects of Environmental Policies

Expanding on the linear regression models of the environmental properties of jobs and job transitions, a variable capturing the stringency of environmental policies at the country level is introduced.¹⁹ Although the estimation of the effects with individual-level

¹⁸This is consistent with more general findings regarding job transitions. Switching occupations is typically less likely than staying in the same occupational category when changing jobs (see Chapter 3 of the April 2021 WEO for further details and selected references).

¹⁹The policy variable of interest is the Organisation for Economic Co-operation and Development’s composite index of the stringency of environmental policies, which combines a country’s measures of carbon pricing and taxation, the extent of research and development spending on green technologies, and the stringency of environmental regulation, among other environmental policy instruments.

observations—which likely do not affect country-level policy settings—and the inclusion of various fixed effects provide some robustness, the findings should be interpreted as associational rather than causal. Moreover, only the statistically significant results are shown here.²⁰

Policies Encouraging Greater Environmental Sustainability Help Green the Labor Market

The analysis suggests that more stringent environmental policies are associated with employment with higher green intensity and lower pollution and emissions intensities. Specifically, the findings suggest that a country that moves from the 25th to the 75th percentile in environmental policy stringency would see a 2 percent increase in its average green intensity of employment; its average pollution and emissions intensities would decline by about 4 and 6 percent, respectively (Figure 3.8, panel 1). In other words, policies that encourage greater environmental sustainability are statistically significantly related to greener employment.

This is in part a reflection of the impact of policies on job transitions. When environmental policies are more stringent, the average green intensity of new-found jobs among workers who switch while employed tends to be higher, and the average emissions intensity of these jobs tends to be lower. For a country shifting from the 25th to the 75th percentile in environmental policy stringency, among those who switch jobs while on the job, their destination jobs have about 4 percent higher average green intensity, while those jobs’ average emissions intensity is about 2 percent lower (Figure 3.8, panel 2).

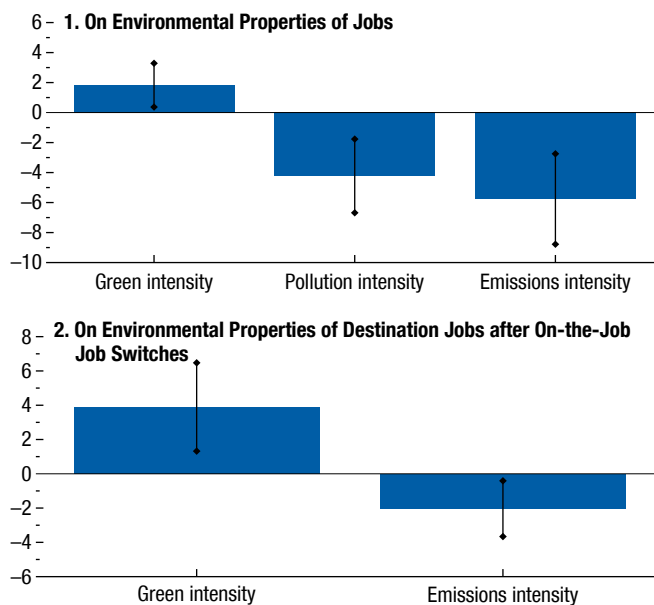
Economy-Specific Labor Market Policies and Structural Features Can Have an Impact on the Effects of Environmental Policies on Employment

These findings on the labor market greening effects of environmental policies point to their role in helping further the green transition. However, these average effects may mask the impacts of differences in countries’ labor market policies and structural features on the effectiveness of environmental policies. This subsection attempts to unpack these effects by considering how they may be mediated by such country-specific characteristics. This is accomplished by adding interactions of environmental policy stringency with selected

²⁰See Online Annex 3.5 for further details on the regression specifications and set of outcome variables considered.

Figure 3.8. Estimated Effects of Environmental Policy Stringency (Percent change)

More stringent environmental policies help green the labor market.



Sources: EU Labour Force Survey; EU Statistics on Income and Living Conditions; US Census, Current Population Survey; and IMF staff calculations. Note: The panels show the average marginal effects of a country’s moving from the 25th to the 75th percentile in environmental policy stringency on the indicated environmental properties, either among all employed workers (panel 1) or among destination jobs after on-the-job job switches (panel 2). The whiskers depict the 90 percent confidence intervals around the estimated effects. See Online Annexes 3.1 and 3.5 for details on the country sample and underlying regression specifications, respectively.

labor market policy and structural feature indicators to the linear regression analysis.²¹

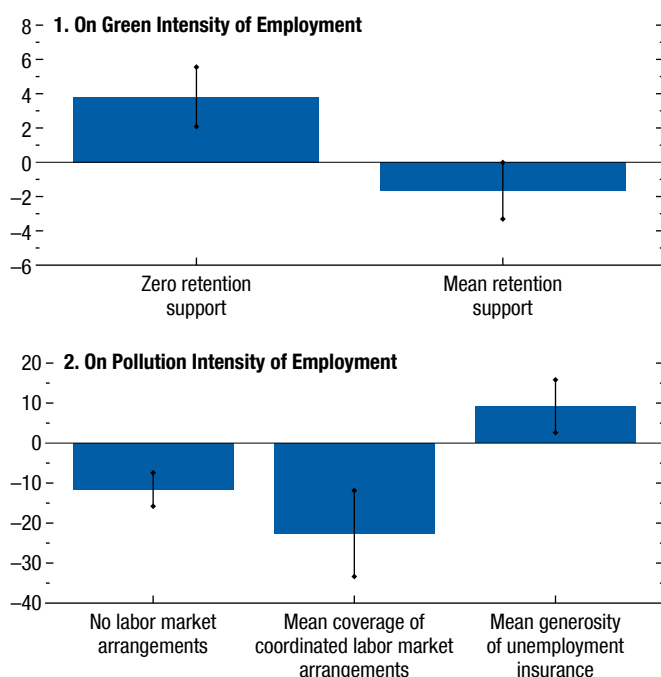
The results suggest that labor market policies and features associated with reduced incentives for worker reallocation tend to dampen the effectiveness of environmental policies in greening the labor market (Figure 3.9).²² In particular, higher spending on job

²¹As mentioned earlier, only statistically significant results are shown here. Other country-specific labor market policies and structural features were investigated but were not found to have statistically significant impacts on the effects of environmental policy stringency on the environmental properties of jobs or related job transitions. These included worker reallocation support measures, the stringency of employment protection regulation, and the stringency of product market regulation. See Online Annex 3.5 for further details.

²²Other structural policies may also influence labor market greening through their effects on geographic allocation within countries. For example, eliminating nontariff internal trade barriers (through activities such as harmonizing occupational licensing within a country) could improve labor reallocation by easing regional labor movements (Alvarez, Krznar, and Tombe 2019; Hermansen 2020).

Figure 3.9. Estimated Effects of Environmental Policy Stringency Conditional on Labor Market Features
(Percent change)

The labor market effects of environmental policy stringency depend on labor market policies and features, particularly those that can inhibit or facilitate worker reallocation.



Sources: EU Statistics on Income and Living Conditions; US Census, Current Population Survey; and IMF staff calculations.
Note: The marginal effect of environmental policy stringency (EPS index) on the environmental properties of jobs is expressed as a percentage of the mean intensity for changes in the EPS index from the 25th to 75th percentiles of the cross-country distribution. The whiskers depict the 90 percent confidence interval around the estimated effects. See Online Annexes 3.1 and 3.4 for details on the country sample and the estimation.

retention support and more generous unemployment insurance are associated with declining effectiveness of environmental policies in spurring, respectively, greater green intensity and lower pollution intensity of jobs. Worker reallocation support (including spending on training programs) is not found to statistically significantly alter the effectiveness of environmental policies, which suggests that it has historically not been designed to support labor market greening. By contrast, the evidence suggests that environmental policies are more effective in reducing the pollution intensity of employment in countries with more coordinated labor market and collective bargaining arrangements. Why might this be the case? Such arrangements could help social partners—businesses, workers, and the

government—coordinate on shared actions to support a green transformation as a common objective and ease any associated labor market adjustment.²³

In summary, the empirical analysis suggests that more stringent environmental policies help promote a greener labor market. Moreover, they tend to be more effective when other labor market policies and features do not inhibit incentives for workers to reallocate and match to new jobs. However, endogeneity, the lack of granularity on alternative policy instruments, and the unprecedented nature of the climate change mitigation challenge argue for caution in extrapolating these empirical findings too broadly. The next subsection attempts to address such concerns through a model-based analysis of policies and their impacts on employment and worker welfare in the green economic transformation.

A Package of Policies for a Greener Labor Market: A Model-Based Analysis

This chapter uses a newly developed task-based, closed economy model to analyze the impact of granular policies on the green economic transformation. As in Acemoglu and Restrepo (2018) and Drozd, Taschereau-Dumouchel, and Tavares (forthcoming), production of goods takes place through the execution of fixed sets of tasks, which vary according to what is produced. Tasks are completed by labor (lower-skilled or higher-skilled) or capital, with varying degrees of cost and productivity. A producing sector's greenness depends on the kind and intensity of inputs used in production, with inputs and tasks varying in their green and pollution intensities (for example, a greener sector produces output with less polluting tasks). For simplicity, the model considers the production of two goods in two sectors that differ in their ultimate emissions intensity (higher/lower), as a function of their production technology and inputs employed.

Capital is used in the production of final goods by both sectors and can substitute for lower-skilled or higher-skilled labor in the execution of tasks, depending on how the relative productivity of capital evolves. However, capital investment requires output from the higher-emissions-intensive sector, similarly to what

²³See Addison (2016) and Blanchard, Jaumotte, and Loungani (2014), among others, which describe how more coordinated and collective labor market arrangements may enhance an economy's ability to adjust to common shocks, particularly when there is trust among social partners.

might be expected for machinery and equipment investment. Hence, to grow the lower-emissions-intensive sector or support greater automation through investment, production in the higher-emissions-intensive sector may rise, at least temporarily.²⁴

Importantly, the model allows for the effects of country-specific characteristics—such as a country's development level—to be assessed through scenarios. The model is calibrated first to a representative advanced economy and then to a representative emerging market economy, drawing on the literature and the empirical findings shown earlier for parameter values.²⁵ There are two main differences between these two economies: (1) the share of overall output coming from the higher-emissions-intensive sector is larger in the emerging market economy, and (2) the difference in the use of labor across the two sectors is larger in the emerging market economy, where production in the higher-emissions-intensive sector is even more reliant on labor. Across both economies, the share of lower-skilled workers in sectoral employment is greater in the higher-emissions-intensive sector.

Rises in the relative price of the higher-emissions-intensive good can shift demand and supply toward the lower-emissions-intensive good, leading to reallocation. This section considers a policy package designed to enable an economy to achieve net zero emissions by 2050 through a mix of productivity improvements and reallocation while smoothing the employment adjustment. Policymakers are able to credibly commit to the policy, enabling investors and workers to plan accordingly. Two elements of the package share similarities with the policies examined in Chapter 3 of the October 2020 WEO:

- An initial green infrastructure and research and development investment push is deployed in 2023 to support a modest productivity increase in the lower-emissions-intensive sector, reducing its production costs per unit of output.²⁶ Spending is slowly reduced after 2028.
- An ad valorem tax on carbon emissions is gradually phased in, starting at about 0.1 percentage point

²⁴Online Annex 3.2 shows that the gap in pollution intensity between routinizable and nonroutinizable jobs is about six times larger than that in green intensity, suggesting that greater automation could be associated with a greener labor market.

²⁵See Online Annex 3.6 for further details, including selected structural and policy parameter calibrations.

²⁶See the Online Annex 3.5 of the October 2020 WEO for discussion and more in-depth analysis of how research and development subsidies targeted to green innovation can facilitate the transition.

per year in 2023 and then rising by 1 percentage point per year from 2029 onward. This raises the relative price of the higher-emissions-intensive good, spurring reallocation and growth in the lower-emissions-intensive sector.

Compared with the earlier study, two new policy instruments are added to the package:

- A training program to facilitate the transition of lower-skilled workers to the lower-emissions-intensive sector is implemented from 2023. This raises the productivity of lower-skilled workers in lower-emissions-intensive work.²⁷
- An earned income tax credit (EITC) program is set up to boost lower-skilled workers' incomes and stimulate their labor supply at the same time. This program starts in 2029, coincident with the carbon tax phase-in.

With this package of policies appropriately timed and tuned, the economy can be put on a green transition path and labor shifts smoothed out.

Advanced Economy Case

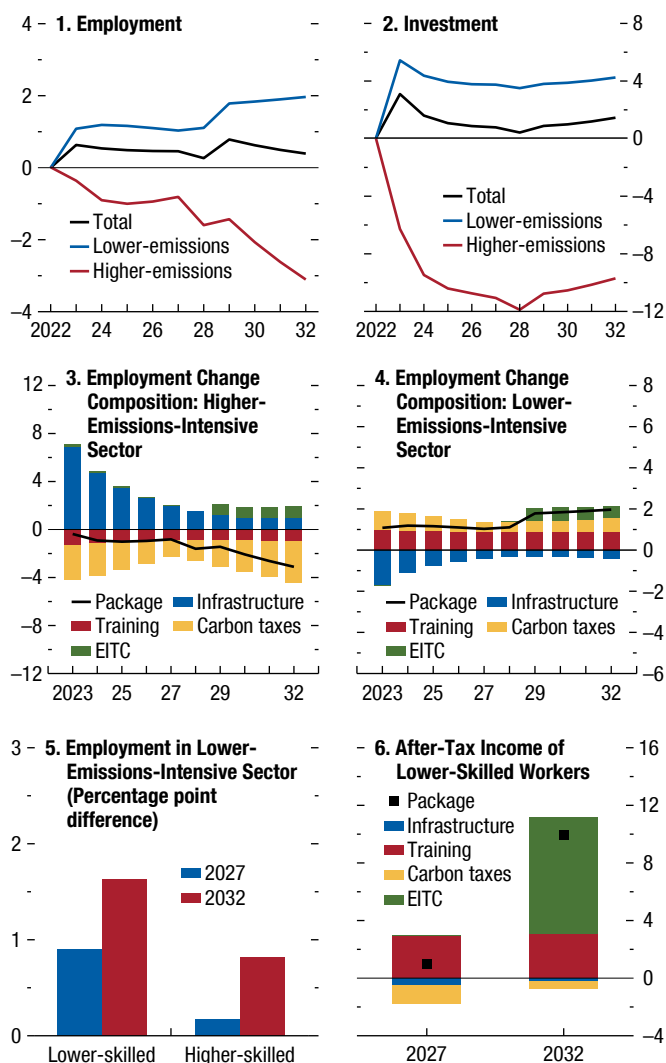
In the case of a representative advanced economy, the policy package generates a labor reallocation of about 1 percent of employment over the next 10 years, shrinking the higher-emissions-intensive sector and growing the lower-emissions-intensive sector (Figure 3.10, panel 1). For the group of advanced economies, the pace of the labor shift is smaller than the average shift of almost 4 percent per decade from industry to services sector employment since the mid-1980s. The package also promotes an increase in capital investment in the lower-emissions-intensive sector, while leading to a sharp fall in investment in the higher-emissions-intensive sector (Figure 3.10, panel 2).

When employment in each sector compared with its baseline is examined, the relative importance of the various policies becomes clear. The green investment push postpones the reallocation of workers initially (Figure 3.10, panels 3 and 4, blue bars), because the push requires capital goods produced by the higher-emissions-intensive sector. By contrast, the carbon tax acts as a price signal, promoting labor reallocation from the higher- to the lower-emissions-intensive

²⁷See Online Annex 3.6 for details on the magnitude of the productivity boost from training. Empirical evidence on the positive effects of training programs supports the argument that training can improve employment prospects for (and reallocation of) targeted worker groups (Card, Kluve, and Weber 2018).

Figure 3.10. Model Simulations of the Green Economic Transformation with a Comprehensive Policy Package in an Advanced Economy
(Percent deviation from baseline, unless noted otherwise)

A comprehensive package with appropriate policy sequencing can bolster the economic and labor market transformations of the economy and labor market needed to achieve net zero emissions by 2050. Training programs and support for low-income workers are key elements for ensuring an inclusive green transition.



Source: IMF staff estimates.

Note: Results shown here are from a model calibrated to a representative advanced economy. The panels show the behavior of the indicated variable in response to a comprehensive policy package, relative to a baseline in which the package is absent. For panels 3 and 4, the effects of the package elements taken individually do not sum to the overall package effect because of interactions in general equilibrium. See Online Annex 3.6 for further details on the model, calibration, and simulations. EITC = earned income tax credit.

sector (Figure 3.10, panels 3 and 4, yellow bars). Moreover, despite the clearly communicated very gradual step-up of the carbon tax over time, businesses and workers anticipate its ultimate impact, starting some reallocation immediately. The training program also helps to promote labor reallocation but does so by making lower-skilled workers more productive in lower-emissions-intensive work (Figure 3.10, panels 3 and 4, red bars). This encourages their hiring by businesses in the lower-emissions-intensive sector and boosts the earnings of those who switch. Finally, the earned income tax credit expansion is not targeted to sectors but instead provides greater incentives for lower-skilled workers to boost their labor supply economy-wide (Figure 3.10, panels 3 and 4, green bars).

Overall, the package generates an increase in total employment of about 0.5 percent.²⁸ Both lower- and higher-skilled workers see higher employment in the lower-emissions-intensive sector, but lower-skilled workers see the largest boost (Figure 3.10, panel 5).²⁹ Moreover, the training and earned income tax credit programs result in an increase in after-tax income for lower-skilled workers, reducing inequality (Figure 3.10, panel 6, red and green bars).

Emerging Market Economy Case

As already mentioned, the emerging market economy case differs from the advanced economy case, given emerging market economies' typically larger shares of output and employment in higher-emissions-intensive production. An emerging market economy is also more likely to have a large share of its labor force in informal employment, which would not benefit from an earned income tax credit. The policy package is thus modified to include a cash transfer to lower-skilled workers. The cash transfer program is not targeted to workers in any specific sector but is available to all low-income (on average, lower-skilled) workers. It is implemented from 2029, alongside the carbon tax and earned income tax credit. Although the cash transfer program could lower income inequality, it could also reduce the incentive to

²⁸This magnitude of the net employment change is closely related to the labor supply elasticity assumed (see Online Annex 3.6).

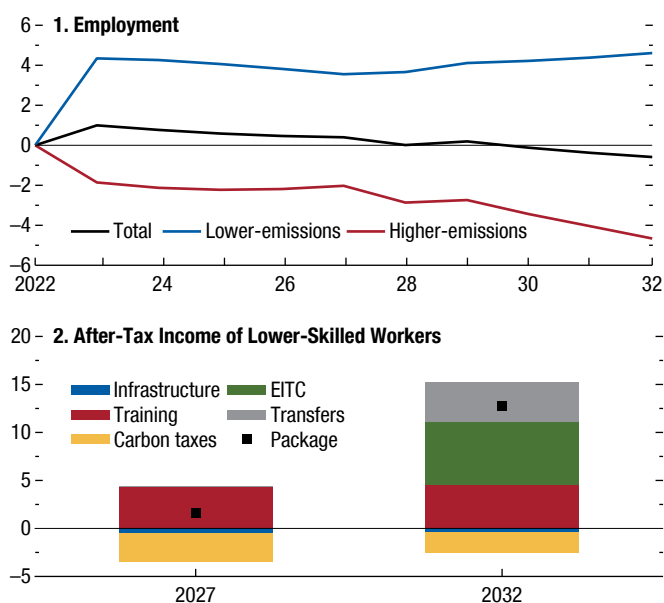
²⁹The model findings imply that labor reallocation contributes about one-seventh of the emissions decline in the policy scenario, with the rest related to efficiency gains. This is a similar order of magnitude to the one-fourth share related to sectoral labor reallocation observed historically in Figure 3.1 for the average sample country over the 2005–15 period.

work, lowering the labor supply. This is an important difference compared with the earned income tax credit.

The policy package in the emerging market economy case generates a larger reallocation from higher- to lower-emissions-intensive sectors compared with the advanced economy case, with about 2.5 percent of employment shifting over 10 years (Figure 3.11, panel 1). The package affects employment through the same channels as earlier, but the initially larger share of employment in the higher-emissions-intensive sector means that a larger part of the economy is affected. There is an overall positive net employment effect in the near term from the investment push, but this changes to a 0.5 percent decline in employment by 2032. Similar to the effect in the advanced economy, the package boosts the income of lower-skilled workers. This comes from the package’s mix of earned income tax credit, training, and cash transfers (Figure 3.11, panel 2).

Figure 3.11. Model Simulations of the Green Economic Transformation with a Comprehensive Policy Package in an Emerging Market Economy
(Percent deviation from baseline)

A similar package in an emerging market economy produces a larger labor reallocation. Lower-skilled workers in the emerging market economy benefit from the greener transition with the policy package.



Source: IMF staff estimates.
Note: Results shown here are from a model calibrated to a representative emerging market economy. The panels show the behavior of the indicated variable in response to a comprehensive policy package, relative to a baseline in which the package is absent. See Online Annex 3.6 for further details on the model, calibration, and simulations. EITC = earned income tax credit.

Conclusions

Reducing the profound downside risks from climate change calls for a green transformation of the economy: production structures must change to lower global GHG emissions. The externalities inherent in the production of emissions mean that policy actions are essential to provide incentives for the needed changes. This chapter investigated the labor market implications of such a green economic transformation, using a mix of empirical and model-based analyses.

The chapter began by quantifying the environmental properties of individual workers’ jobs through three different metrics, reflecting how green, polluting, and carbon-emitting each job is. More green- and pollution-intensive jobs both appear to be concentrated among subsets of workers: economy-wide average green and pollution intensities are relatively low. Still, there is a wide dispersion of these environmental properties across and within sectors, suggesting the capacity exists for labor reallocation along both dimensions. Of particular note, industrial sectors tend to be simultaneously more green-, pollution-, and emissions-intensive than services.

Second, the chapter looked at the relationship between workers’ demographic characteristics and the environmental properties of their jobs. It found that more green-intensive occupations tend to have higher-skilled and more urban workers, while the opposite is true for more pollution-intensive jobs. Importantly, even after skills are controlled for, green-intensive jobs exhibit an earnings premium—almost 7 percent—compared with pollution-intensive jobs on average.

Third, reallocation could be challenging for individual workers. The chapter found that a worker with a history of more pollution-intensive or neutral jobs is less likely to move into a more green-intensive job than to stay in pollution-intensive or neutral work. Higher skills do make for an easier match to a more green-intensive job, pointing to the importance of a worker’s human capital in easing transitions.³⁰ Targeted and effective training programs to boost the human capital of lower-skilled workers in pollution-intensive or neutral occupations could help, by improving these workers’ ability to move into more green-intensive occupations.

³⁰See Online Annex 3.4 for discussion of how a worker’s demographic characteristics are related to the environmental properties of jobs after transitions.

Fourth, environmental policies are effective in shifting employment toward greener jobs, but such policies work best in economies in which incentives for reallocation are not inhibited. This points to the importance of moving from job retention to measures that support worker reallocation as COVID-19 shifts from pandemic to endemic. Recent labor market dynamics indicate that greener employment was relatively more resilient during the COVID-19 recession (Box 3.2).

Critically, the model-based analysis suggests that the right policy package can put an economy on the path to net zero emissions by 2050 with moderate shifts in employment. Similar to that presented in earlier work, the package involves a green infrastructure push and carbon tax, but paired with two new elements to improve labor market functioning and address distributional concerns: a targeted training program to boost the productivity of lower-skilled workers in lower-emissions-intensive work and an earned income tax credit—which helps offset any consumption shock from carbon taxes for lower-income workers and incentivizes labor supply. Where informality in employment is high, the earned income tax credit should be supplemented with cash transfers for income support, targeted toward those most likely to be working informally.

For a representative advanced economy, the package entails technological and productivity improvements and a shift of about 1 percent of employment into the lower-emissions-intensive sector over 10 years. This package also buffers the unequal impacts of the carbon tax on low-skilled workers, reducing income inequality. To provide some sense of the magnitude of this shift, it involves a smaller labor reallocation than the average shift of almost 4 percent of employment per decade from work in industrial to services sectors that has been observed in advanced economies since the mid-1980s.³¹ With the earned income tax credit, the package actually helps boost total employment over the long term by about 0.5 percent.

For a representative emerging market economy, the employment shifts from the policy package are larger—about 2.5 percent—reflecting emerging market economies' initially greater shares of more emissions-intensive production and higher shares of lower-skilled workers. Employment increases over the

³¹This employment shift may in part reflect reallocation as a result of automation, although measuring its exact contribution is difficult, and it likely varies by country (Acemoglu and Restrepo 2020; Dauth and others 2021).

near term, as the infrastructure boost draws workers in, but then declines, ending up about 0.5 percent lower after 10 years. This reflects the need to rely more on cash transfers than the earned income tax credit to provide income support to the informally employed, translating into a smaller boost to labor supply. However, the package still improves income inequality.

Climate change mitigation actions will touch all aspects of the economy, many of which lie outside this chapter's focus on the labor market. Modest policy-induced technological and productivity improvements are critical for achieving net zero emissions without large output drops and large-scale labor shifts.³² The green energy transition will also likely require extensive new capital investments, which could prove costly in the near term.³³ Within-country regional concentrations of more pollution-intensive occupations and higher-emissions-intensive production could mean that the burden of adjustment is shared unevenly geographically, particularly if policy measures to ease the transition (such as training programs and other reallocation support) are ineffectively implemented. Because of lack of data, the chapter was unable to delve into issues facing the agricultural sector, which are particularly important for many low-income developing countries. Finally, the chapter abstracted away from the international dimensions of climate change policies, in which potential leakages and cross-country spillovers argue for a global, coordinated approach.³⁴

An overall picture emerges that the size of labor shifts required for the green transition is not unprecedented. That said, the exact size and speed of the needed reallocation will vary by country (and within country, by region), depending on the importance of higher-emissions-intensive production in the

³²See Online Annex 3.6 for further discussion of the model's incorporation of technology and productivity improvements and their relative importance.

³³Among others, see IEA (2021) for a recent discussion of the energy transition and capital costs. Capital investment increases are also needed to address climate change adaptation (Chapter 2 of the October 2020 *Fiscal Monitor*). For discussion of the magnitude of financing shifts required and how financial market regulation (including climate-related data standards and disclosures) can support the green transition and adaptation, see Chapter 5 of the April and October 2020 *Global Financial Stability Report* (GFSR) and Chapter 3 of the October 2021 GFSR.

³⁴See Chapter 3 of the October 2020 WEO for an example of such a globally coordinated policy package and Chateau, Jaumotte, and Schwerhoff (2022) for mechanisms to facilitate international coordination.

local economy and whether policy actions to get on the net zero emissions path are delayed. From an individual-level perspective, the road appears rougher, as workers with pollution-intensive or neutral job backgrounds find it harder to move into more green-intensive jobs. Any policy package should thus

include elements that aim to ease the transition for these workers—policies that enhance their employability, like well-designed training programs, and boost their ability to find new job matches—and ensure that the path to a greener labor market is a smooth and inclusive one.

Box 3.1. The Geography of Green- and Pollution-Intensive Jobs: Evidence from the United States

The within-country distribution of green- and pollution-intensive jobs offers insights into the challenges of transitioning to a greener economy by region. If green-intensive jobs are also present in regions currently more reliant on more pollution-intensive employment, the green transition may require less geographic reallocation of workers. Depending on the country, the geographical distribution could also have political economy implications.

*There are signs of geographic concentration of higher green and pollution intensities.*¹ On average, jobs are more green-intensive in the US West and Southwest, with pockets of intensity in the Midwest (Figure 3.1.1, panel 1). Notable subsectors in regions with green-intensive jobs include research and development, engineering services, and aerospace manufacturing. Jobs have higher pollution-intensity in the Southeast and Southwest and are found especially in extractive industries, electric power (generation, transmission, and distribution), and wood and textile industries (Figure 3.1.1, panel 2).

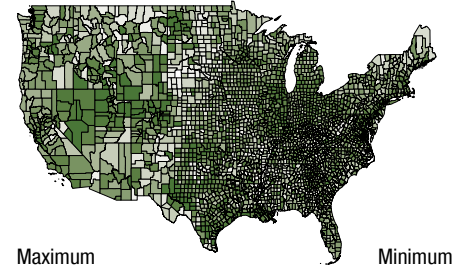
Areas with more green- and pollution-intensive jobs tend to overlap. Geographic frictions can impede the green transition, especially if labor mobility is declining (Chapter 2 of the October 2019 *World Economic Outlook*; Dao, Furceri, and Loungani 2017). However, areas rich in green-intensive jobs tend to border on or overlap with pollution-intensive-job-rich areas. Of 173 US commuting zones rich in pollution-intensive jobs (above the 75th percentile), 125 either are also rich in green-intensive jobs (above the 75th percentile) or border a commuting zone rich in such jobs. This proximity does not guarantee the transition will be easy: policy measures such as effective training programs remain important. There are differences between areas with either more green- or more pollution-intensive jobs. More green-intensive jobs tend to be more urban, while more pollution-intensive jobs tend to be rural. Counties with a higher share of more green-intensive jobs also tend to have higher incomes, younger

The authors of this box are Katharina Bergant and Rui Mano.

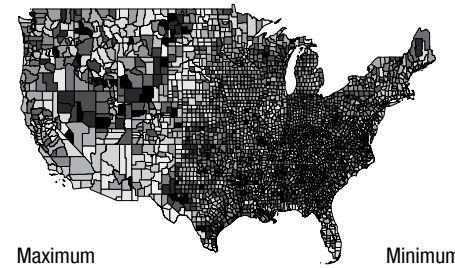
¹Online Annex 3.7 provides further details on the data and analysis exhibited.

Figure 3.1.1. Geographic Distribution of Green and Pollution Intensities across US Counties

1. Green-Intensive Jobs



2. Pollution-Intensive Jobs



Sources: US Bureau of Labor Statistics, Occupational Employment and Wage Statistics; US Census, County Business Patterns; and IMF staff calculations.

Note: These maps use a relative coloring scheme, such that greener (grayer) coloring means that employment is more green-(pollution)-intensive in a relative rather than an absolute sense. Estimates of green-(pollution)-intensive jobs combine three data sets: (1) definitions of green/polluting occupations (see Vona and others 2018), (2) industry-state occupational breakdowns from the Occupational Employment and Wage Statistics data set, and (3) county-industry employment (from County Business Patterns, as harmonized by Eckert and others 2021).

populations, a greater proportion of people with a college degree or more education, and lower unemployment. Unionization is negatively related to the share of pollution-intensive jobs but shows no relationship to green intensity.

Box 3.2. A Greener Post-COVID Job Market?

Official labor force surveys can provide an in-depth picture of the evolution of greener employment. However, these surveys are usually published with lags, making it challenging to track whether the ongoing COVID-19 recovery has accelerated or decelerated labor market greening. High-frequency data from online job networking and search platforms can help provide timelier insights.

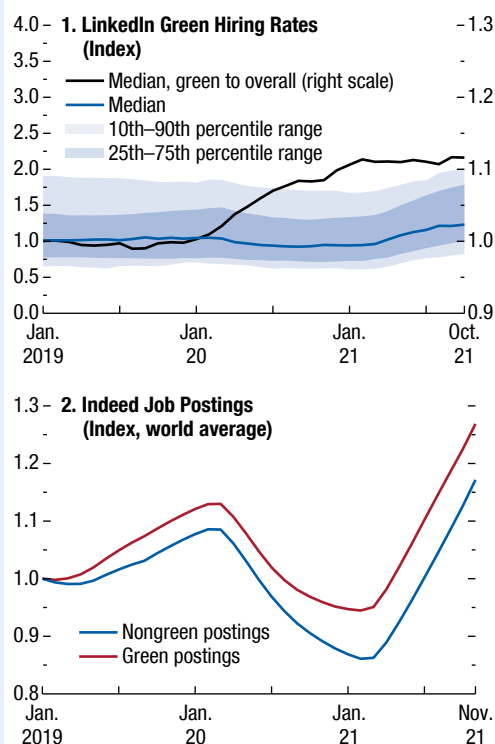
Recent patterns in hiring rates suggest greener jobs were relatively more resilient throughout 2020. Using self-reported worker profiles and expert judgments, LinkedIn identified green skills and categorized workers according to their “green talents.”¹ Similarly to the motivation for the green intensity definition with respect to tasks used in this chapter, the classification reflects whether workers report skills that improve the environmental sustainability of economic activities (for example, pollution mitigation, waste prevention, and green energy generation and management). By using information on workers’ employment changes, gross hiring rate indices can be computed to follow short-term hiring fluctuations. Hiring rates for green talent workers were better than that for all jobs in the early months of the pandemic and ticked up over 2021 as the recovery strengthened (Figure 3.2.1, panel 1).

Developments in job postings also suggest more resilient demand for greener workers. Although not linked to the green skills classification presented in the previous paragraph, job postings data from the online platform Indeed can be matched to sectors, which can in turn be categorized as having above- or below-average green intensities. Based on this split, world average green job postings declined less than nongreen postings during the pandemic (Figure 3.2.1, panel 2). This resilience was broad-based, as green sector postings experienced smaller declines in 28 of the 34 countries in the sample. Moreover, paralleling the pattern seen in hiring rates, bounce-backs in job postings have been similar in both green and nongreen sectors during the recovery. Overall, a picture emerges of some labor market greening early in the post-COVID recovery, which has now stalled.

The author of this box is Jorge A. Alvarez.

¹See Online Annex 3.7 for further details on the LinkedIn and Indeed data sets.

Figure 3.2.1. Cross-Country Evolution of Green Hiring Rates and Job Postings



Sources: Indeed; LinkedIn; and IMF staff calculations.

Note: Panel 1 shows cross-country percentiles standardized to the median observed in January 2019. The hiring rate is a measure of hires normalized by LinkedIn membership. It is computed as the percentage of LinkedIn members who added a new employer in the same period the job began, divided by the total number of LinkedIn members in the corresponding location. The green hiring rate is computed considering only members classified as green talent. Workers are considered green talent if they have explicitly added at least one green skill to their profile, are occupied in a green occupation, or both. Panel 2 shows a cross-country 12-month average job postings index, standardized to January 2019. Green postings refer to postings on the Indeed platform associated with sectors that have above-average green skill intensity. See Online Annex 3.7 for further details.

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