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Green Jobs and the Future of Work for Women and Men

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ABSTRACT: The transition to a sustainable and green economy requires workers to move out of carbon-intensive jobs and move into green jobs. The pace and effectiveness of the transition hinge not only on climate policies but also on the skills and adaptability of workers. Evidence suggests that economies with a robust supply of science, technology, engineering, and mathematics–educated workers and a more equal treatment of women are better placed to transition faster and at a lower cost to a green economy, even after controlling for other country characteristics, because these economies generate more green innovation and face lower bottlenecks in expanding the green workforce. Altogether, climate policies, particularly energy taxes, in these economies are associated with reductions in greenhouse gas emissions intensity that are 2 to 4 percentage points larger than in economies with a less inclusive and educated workforce. While green jobs have been growing worldwide, men currently hold close to two-thirds of these positions and women only one-third. Green jobs are associated with a 7 percent premium for men and an even higher premium of 12 percent for women, suggesting that men's and women's labor supply may not meet demand. These findings highlight the critical need for educational and labor policies that promote skill enhancement and gender inclusivity, to ensure a sufficient supply of workers for the green economy and that all workers can benefit from the green transition. Finally, artificial intelligence could be beneficial for workers in green jobs.

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Contents

Executive Summary

The green transition presents both significant opportunities and challenges for workers across advanced economies (AEs) and emerging market and developing economies (EMDEs). Green jobs are employing a growing number of workers globally, reflecting a shift toward sustainability. In contrast, polluting jobs are declining in importance in AEs but continue to rise in EMDEs. This note explores how investments in science, technology, engineering, and mathematics (STEM) skills and reforms for women's economic empowerment are key for workers to grab the opportunities brought by the green transition. Our findings suggest that economies with a robust supply of STEM-educated workers and more equal gender treatment could transition faster and at a lower cost to a green economy.

Broadening the pool of workers in green jobs would not only make the green transition more inclusive but could also increase the effectiveness of climate policies. Evidence suggests that energy taxes are associated with larger reductions in greenhouse gas emissions intensity—by 2 to 4 percentage points—in countries with a larger supply of STEM-educated workers and more equal treatment of women. This holds even after controlling for tertiary education rates, institutional quality, income level, and past growth. STEM-educated workers and gender equality policies appear to stimulate green innovation and green employment, reducing bottlenecks.

Green jobs are currently associated with a wage premium, which is even larger for women, suggesting labor supply may not meet the demand from firms. The green wage premium is about 7 percent on average for men and 12 percent for women after controlling for workers' and sectoral characteristics, resulting in a smaller gender pay gap in green jobs than for other jobs in the economy. Moreover, green jobs are well-suited to benefit from artificial intelligence, which could boost their productivity and wage potential over time.

Despite green jobs being a growing source of employment, women are strongly underrepresented, raising concerns about the gender-inclusiveness of the green transition. In both AEs and EMDEs, only one-third of those jobs are held by women, making them a less significant employment source for women compared to men. Green jobs among college-educated workers are concentrated in STEM, suggesting that most of the green gender employment gap among college-educated workers could be attributed to the gender gap in STEM degrees and, to a lesser extent, to the managerial gender gap. Among workers without a college degree, the green gender employment gap mirrors a gender gap in manual jobs.

Workers may also face specific vulnerabilities in the green transition. For example, in Brazil, Colombia, and South Africa, the decline in polluting jobs, which are typically held by middle-class workers, coupled with the increasing demand for green jobs, which are usually higher earners' jobs, may lead to heightened income inequality and worsen the hollowing out of the middle class. This phenomenon would be exacerbated for emerging markets, which have a higher proportion of such jobs than AEs.

Tackling the identified disparities and vulnerabilities can help make the green transition more effective and inclusive. Policies should aim at enhancing STEM education, strengthening mentoring programs, and providing exposure to female role models in STEM. STEM degrees are not only key for the green transition, but also for overall technological progress and economic growth. Governments should support women's participation in the economy by reducing labor market barriers, improving access to finance, removing legal barriers, using gender budgeting, reforming legal frameworks, and increasing women's board representation. Policies to help workers in declining polluting industries include retraining, place-based investments, and strengthening social safety nets. While some of these policies, such as investing in STEM education and childcare, may require short-term government costs, research has shown that the long-term benefits are larger than the costs. The green transition offers a unique chance for a more inclusive workforce. It is imperative that policymakers, the private sector, and civil society seize this moment to forge a sustainable and inclusive future.

Introduction

As the world confronts the urgent demands of climate change and environmental degradation, the transition toward a sustainable economy has become critical for nations worldwide. This transformation necessitates steering the global workforce away from carbon-intensive and environmentally harmful jobs toward employment that contributes to reducing greenhouse gas (GHG) emissions and maintaining a low carbon footprint. Such a shift will require the active participation of both advanced economies (AEs) and emerging market and developing economies (EMDEs), with green jobs emerging as both a driver and a consequence of the green transition.

To be sustained, the green transition needs to be inclusive and ensure all groups of population can find a place in the new green economy.[2] Understanding the characteristics of green and polluting jobs, as well as their distribution across population groups, in particular along the gender and income level dimensions, is thus crucial to identify which groups may lose from the transition away from polluting sectors, or not benefit from the expansion of the green economy absent policy support. This analysis will enable policymakers to target policies to ensure a more inclusive future of work for women and men.

Meanwhile, policies that promote inclusiveness by laying the foundations for participation in the green economy may also facilitate the green transition and reduce its cost. Green jobs, defined by the occupation's role in improving environmental sustainability and reducing GHG emissions, are essential for the transition. Whether in renewable energy, energy efficiency, waste management, or sustainable agriculture, these occupations are pivotal in reducing emissions, conserving resources, and minimizing waste and pollution. Economies that already possess a large and diverse workforce prepared to work in green jobs will likely more readily adapt to sustainable practices, innovate, and decarbonize the economy more effectively.[3] Therefore labor market conditions and the composition of the workforce can determine the pace of the transition process and impact the effectiveness of environmental policies.

Gender diversity in green jobs can help with the green transition through three main channels. These are (1) increasing environmental concern, (2) enhancing the allocation of talents, and (3) stimulating innovation. First, studies suggest that women tend to be more climate conscious (McCright 2010; Franzen and Vogl 2013; Clayton and others 2023), which may lead to more environmentally friendly decision making in various sectors. Studies have shown that a higher share of female managers within firms results in larger declines in carbon dioxide emissions (Altunbas and others 2022), and banks with gender-diverse boards are more likely to lend to green firms and reduce loans to high-pollution firms (Gambacorta and others 2022). Second, by reducing barriers and biases hindering women's full economic participation, talent allocation can be improved and the complementary skills of men and women can be leveraged, leading to significant productivity gains. This is likely to be particularly important for green jobs because the employment gender gap in green jobs is larger than in other jobs in the economy. Therefore, the benefits of bringing more women to green jobs are also likely to be more significant. Finally, gender diversity within firms and a better prepared workforce foster innovation, as diverse perspectives drive the development and implementation of sustainable practices and technologies essential for a successful green transition.

[2] This note focuses on the gendered impact of the green transition on the labor markets, leaving out other important considerations such as the disproportionate impact of climate change on women, the critical role of women in adaptation strategies, and the inequalities in the distribution of climate funds (Deininger and others 2023).

[3] Adão, Beraja, and Pandalai-Nayar (2022) show the importance of workers' skills to determine the speed of technology adoption.

Ultimately, the share and type of workers engaged in green jobs and returns associated with these jobs will depend on both the supply and demand for these workers. On the demand side, climate policies and the adoption of technologies facilitating the green transition are increasing the demand for such workers. On the supply side, the proportion of workers possessing the necessary science, technology, engineering, and mathematics (STEM) skills, overall labor market tightness, and workers' preferences for STEM versus non-STEM fields may be constraints on the supply of workers for the green economy, leading to wage premiums in these fields. Policies that boost STEM education or improve women's opportunities in labor markets could help increase the supply of workers for the green economy and address imbalances in these markets. Our analysis primarily focuses on the short- to medium-term impacts of the green transition on the labor market, considering current technologies, worker characteristics, and climate policies, particular energy taxation. We identify potential barriers that firms and governments may face in expanding the share of workers in green jobs. Understanding these barriers is essential for designing effective policies and interventions that support a smooth transition to a green economy.

Against this backdrop, this note aims to answer four critical questions:

1. How are green jobs distributed across countries, and how have they evolved recently?
2. What is the expected impact of the green transition on the future of work for women and men?
3. How can policymakers support a more inclusive and gender-neutral green transition?
4. How can the supply of STEM workers and gender parity influence the effectiveness of green policies?

This note builds upon a growing body of work that has explored the evolution of green jobs, especially in the context of AEs. In this literature, green jobs are defined at the occupation level and depend on the task content of each occupation, while polluting jobs are characterized by their sectoral employment; examples of green occupations include electrical engineers and refuse workers, while polluting jobs include petroleum engineers and garment workers. Much of this literature has focused predominantly on AEs, as seen in studies by Vona and others (2018), Bluedorn and others (2023), and the Organisation for Economic Co-operation and Development (OECD) (2023a). These studies have laid the groundwork for understanding how the green transition influences employment dynamics, revealing that a considerable proportion of the workforce is employed in green jobs. Typically, these positions are occupied by individuals with higher education who often enjoy a wage premium associated with their jobs. Additionally, these analyses highlight a pronounced gender disparity within green job sectors, where women are notably underrepresented.

We provide a deeper analysis and extend this work to show how labor market characteristics such as the availability of STEM skills and gender parity policies may also impact the effectiveness of climate policies, a point absent in previous studies. First, we explore the implications of the green transition for jobs beyond AEs. We find that the impact of the green transition on labor markets is set to vary significantly across nations, influenced by each country's economic structure and initial levels of emissions. We find that emerging markets, represented in our analysis by Brazil, Colombia, and South Africa, may face more profound shifts in polluting sectors than AEs, such as the United Kingdom and the United States analyzed in this note, due to their traditionally larger manufacturing sector and higher carbon emission intensity of output.[4] Second, we examine the underlying causes of women's large underrepresentation in green jobs by country and educational groups and find that gender gaps in STEM education, as well as in managerial and manual occupations, are key drivers. Third, we highlight that green jobs should be particularly beneficial for women who can access them, as the gender pay gap is currently smaller in these occupations than in the rest of the economy. Additionally,

[4] IMF (2022a) finds that reducing emissions in emerging markets requires a larger shift in employment than in AEs.

women in green jobs are in occupations that are likely to benefit from artificial intelligence (AI), which could further boost their productivity. Fourth, we show that a greater supply of STEM graduates and greater gender parity are associated with greater effectiveness and reduced cost of environmental policies.

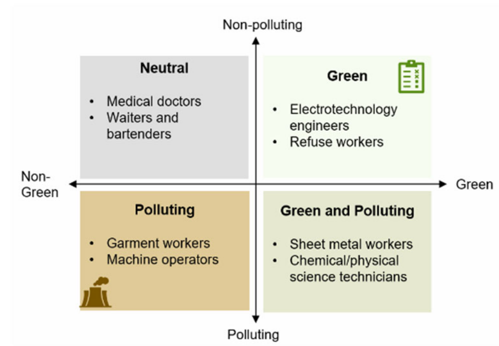
The remainder of the note is structured as follows. The second section outlines the conceptual framework for green jobs and documents the extent of green and polluting jobs across countries and their recent evolution. It also details the distribution of green jobs by gender and the main forces behind the gender gap in green jobs. It discusses the characteristics of workers in polluting jobs and explores the distribution of these jobs across the income distribution. Additionally, this section examines the green wage premium and the gender pay gap in green jobs across countries. The third section examines the future of green jobs by discussing the importance of policies for greater STEM education and gender equality. The fourth section explores the interconnection between the effectiveness of environmental policies and labor market characteristics and concludes by applying a multisector general equilibrium model to quantify the importance of labor market characteristics for the effectiveness of green policies, and their implications for inequality and welfare. The final section concludes with policy considerations.

Impact of Green and Polluting Jobs

Identifying Green and Polluting Jobs

To better understand how the pace of the transition can be increased as well as the impact that the green transition will have on labor markets, this note investigates two critical attributes of an occupation: the task content of the occupation (that is, the activities performed by workers) and the sector of employment (that is, where they work). The task content of an occupation determines both the green intensity of the occupation and whether the occupation is classified as green (contingent on the level of green intensity). In contrast, the sector of employment determines whether an occupation is classified as polluting.

Figure 1. Different Measures: Green (Composition of Skills) and Polluting (Sector of Work)



Source: Alexander and others (2024)
Note: The figure shows the four main groups of occupations analyzed in the paper. The groups are green, green and polluting, polluting, and neutral jobs.

Green jobs are identified using a bottom-up approach. For this measure, an occupation is viewed as a bundle of tasks that a job requires. The underlying set of tasks for each occupation is classified into either green or non-green tasks, following Dierdorff and others (2009). A green task is one that directly improves environmental sustainability or reduces GHG emissions. An occupation is classified as green if more than 5 percent of its tasks weighted by the task importance are green, similar to OECD (2023a).[5] The use of a threshold increases the share of green jobs in the economy, compared to previous studies like Bluedorn and others (2023) and Bergant, Mano, and Shibata (2022) that focus on the green intensity content of employment.

Polluting jobs are identified at the sectoral level in a two-step process following Vona and others (2018) because there is no similar task taxonomy for polluting jobs. Initially, a sector is identified as polluting if the sector's emissions per worker for at least three polluting substances (carbon monoxide, volatile organic

[5] See Alexander and others (2024) for a more detailed discussion about the threshold effects.

compounds, nitric oxides, sulfur dioxide, PM10, PM2.5, lead, and carbon dioxide) fall within the top 5 percent of polluters. Subsequently, the share of the occupation employed in the sector must be at least seven times larger than in other sectors to assure that this is a relevant sector for the occupation.[6] Given the metrics for green and polluting address different job aspects (the tasks performed versus the employment context), occupations can simultaneously be green and polluting. Consequently, jobs are categorized into four distinct types: (1) green (green tasks within a non-polluting sector), (2) green and polluting (green tasks within a polluting sector), (3) polluting (non-green tasks in a polluting sector), and (4) neutral (non-green tasks in a non-polluting sector). For instance, electrical engineering technicians fall into the International Standard Classification of Occupations (ISCO) group "technicians and associate professionals" and exemplify green, non-polluting occupations, with green tasks that include building components of electrical vehicles, assembling solar photovoltaic products, and creating electrical components to be used in renewable energy generation. Refuse workers also exemplify green, non-polluting jobs but fall into the lowest-skill ISCO group "elementary occupations," with green tasks that include sorting items for recycling and operating equipment that compresses refuse. Sheet metal workers in the occupational group "crafts and related trades" are both a green and polluting job—undertaking green tasks such as performing work necessary for solar panel installation and constructing components for wind turbine systems while working in a polluting sector. Garment workers, also in the occupational group "crafts and trades," illustrate polluting, non-green jobs with a large presence in polluting sectors and no green tasks. Medical positions are classified as neutral with no green tasks and in a non-polluting sector. Figure 1 represents the note's analytical framework, including examples for each job category.

This note applies the described job categories across countries and demographic groups by measuring the share of workers in each type of occupation. The aggregated data, provided by the International Labour Organization at the three-digit ISCO level, offers a broad perspective on trends in green and polluting jobs. In contrast, the more granular data, sourced at the four-digit ISCO level from labor force surveys in five countries—Brazil, Colombia, South Africa, the United Kingdom, and the United States—enables detailed analysis of workers' characteristics and the economic returns associated with green and polluting jobs.

This methodology carries important limitations. First, it does not consider the significant role of worker reallocation and the ease with which workers can transition from certain occupations to green occupations. Additionally, it relies on the current definition of green tasks without accounting for potential changes in the demand for green tasks or the creation of new green tasks. Third, it assumes an occupation encompasses the same tasks in each country, although significant cross-country variations within occupations may exist. Fourth, it may overestimate the polluting jobs at risk as over time the development of low-carbon technologies may enable polluting sectors to keep operating by electrifying and using clean energy–operated machines. Despite these limitations, the analysis provides a valuable snapshot of the current distribution of green jobs and highlights possible barriers to the expansion of the green economy in the near future.

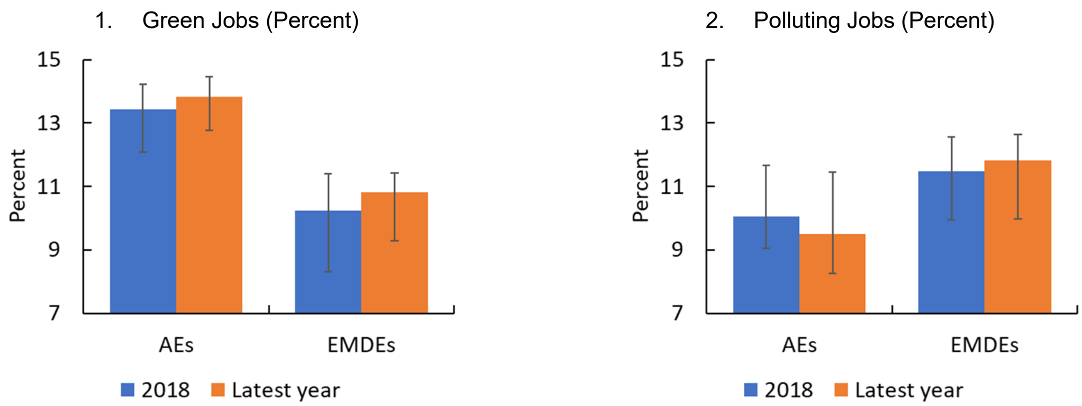
Prevalence of Green and Polluting Jobs across Countries

Green jobs account for about 10 to 15 percent of employment and are slightly more prevalent in AEs than in EMDEs. On average, recent data shows that 14 percent of workers in AEs are employed in green jobs, compared to approximately 11 percent in EMDEs (Figure 2). Notably, there is considerable variation within these country groups, especially among EMDEs.

[6] Vona and others (2018) also considered cutoffs of 5 and 10 times higher; however, the authors argue that seven times delivers a better mix of polluting-relevant occupations.

On average, green jobs have gradually increased in all countries, while polluting jobs, which are more common in EMDEs, are declining in AEs but rising in EMDEs. Since 2018, the proportion of green jobs has risen from 13.4 to 13.8 percent in AEs and from 10.2 to 10.8 percent in EMDEs. Additionally, a decline in variance across countries indicates that more nations are progressing toward a sustainable economy. The proportion of the workforce employed in polluting jobs is significantly lower than that in green jobs in AEs—at 9.2 percent versus 13.8 percent—but the situation is reversed in EMDEs. There, polluting jobs account for 12.5 percent while green jobs make up 10.8 percent of employment. Also, while the share of workers in polluting jobs has decreased by more than 0.6 percentage point in AEs over the last five years, the share of workers in polluting jobs has increased by almost 0.4 percentage point in EMDEs. Despite the emphasis on green and polluting jobs, most workers are neither in green nor polluting jobs, with neutral jobs accounting for about 77 percent of employment on average.

Figure 2. Green and Polluting Jobs



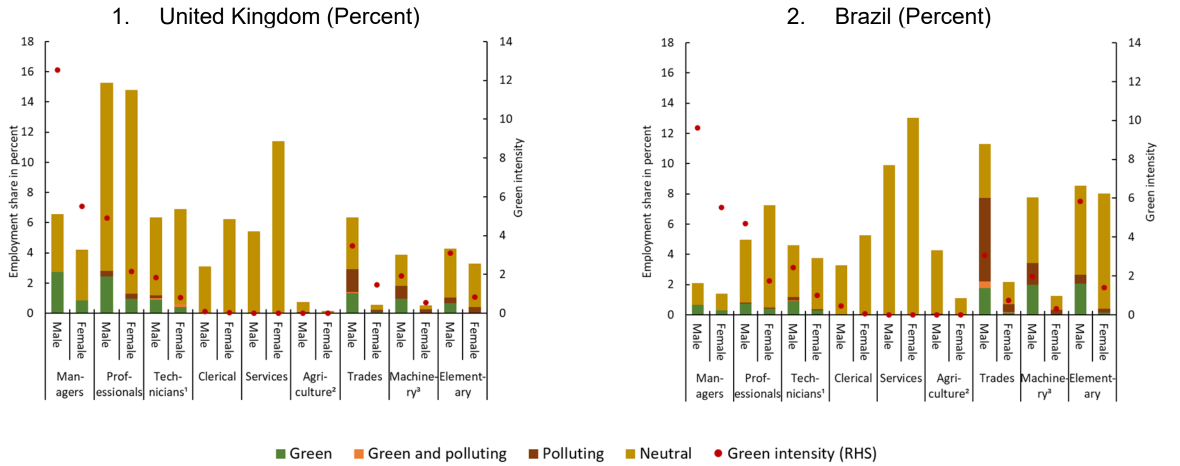
Sources: ILO calculations based on data from the ILO Harmonized Microdata Repository[7]; and IMF staff calculations.
Note: The figure shows the share of green , polluting jobs. Both plots are based on the same balanced sample of 44 countries including 25 AEs and 19 EMDEs with available employment data at three-digit ISCO-08 code from the ILO. The whiskers denote 25th and 75th percentiles. A total of 2, 38, and 4 countries have the latest data in 2021, 2022, and 2023, respectively. AEs = advanced economies; EMDEs = emerging markets and developing economies; ILO = International Labour Organization; ISCO = International Standard Classification of Occupations.

Unlike polluting jobs that are concentrated in manual occupations in AEs and EMs, the distribution of green jobs is very different across countries. Green jobs in AEs are concentrated among managerial and professional occupations, while in EMDEs, these jobs are largely found among craft and trades, plant and machine operators, and elementary occupations (Figure 3). For instance, in Brazil, these latter categories represent 66 percent of green jobs, including occupations such as refuse workers, building construction laborers, and heavy truck drivers.[8] In the United Kingdom, managerial and professional categories account for 73 percent of green jobs, encompassing professions like engineering professionals and financial and investment advisors. Within major occupations, green intensity is similar across countries.

[7] ILO data based on Bescond and others (2024a; 2024b).

[8] Heavy truck driving is considered a green occupation because the workers perform important tasks for the green transition, including adjusting routes to reduce emissions, driving electric or hybrid electric trucks or alternatives, operating idle reduction or auxiliary power systems from alternative sources for energy, and providing power for other equipment (O*NET Center 2021).

Figure 3. Worker Occupations, by Gender (Selected Countries)



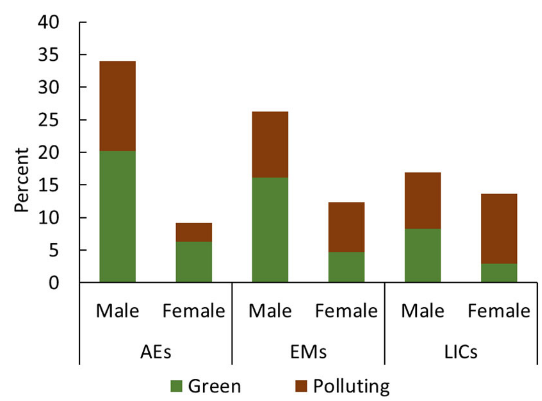
Sources: Pesquisa Nacional por Amostra de Domicilios Continua (Brazil, 2022); Labor Force Survey (United Kingdom, 2022); and IMF staff calculations.
Note: The figure plots the share of employment in each quadrant for each country across the one-digit ISCO-08 occupation codes and by gender. The primary *y*-axis measures the employment share of green, green and polluting, polluting, and neutral jobs in each country in percent. The secondary *y*-axis plots the green intensity of each major ISCO-08 group in each country, also in percent. ISCO = International Standard Classification of Occupations.
[1] Technicians and associate professionals.
[2] Skilled agricultural, forestry, and fishery workers.
[3] Plant and machine operators and assemblers.

Gender Imbalances in Green and Polluting Jobs

Men significantly outnumber women in green jobs across AEs and EMs (Figure 4). In AEs, green jobs account for 20.3 percent of men's employment, contrasting sharply with just 6 percent for women. The gap is similarly wide in EMs, where 16 percent of men's jobs are green, compared to only 4.6 percent for women. Surprisingly, despite the large differences in economic development between these groups of countries, the gender distribution remains strikingly consistent, with more than two-thirds of green jobs occupied by men and only one-third by women. The gender gap in green employment is also wider and more consistent than the gender gap in overall employment. Using the same sample, the employment gender gap is 6 percentage points in AEs, 30 percentage points in EMs, and 17 percentage points in low-income countries (LICs).

Figure 4. Employment Share, by Gender

(Percent)

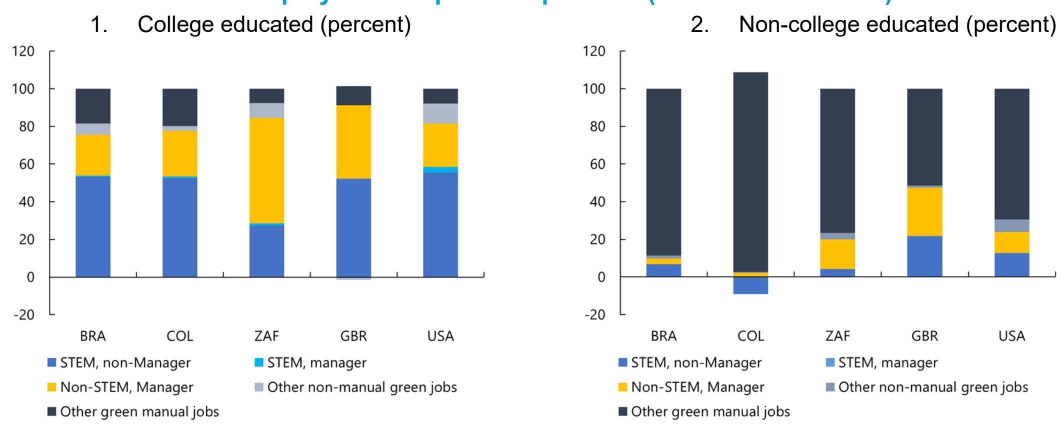


Sources: ILO calculations based on data from the ILO Harmonized Microdata Repository; and IMF staff calculations.
Note: The figure plots the employment share of green and polluting jobs by gender, across AEs, EMs, and LICs. The denominator is respectively total male and female employment. The plots are based on a sample of 98 countries including 25 AEs, 50 Ems, and 23 LICs with the latest available employment data at three-digit ISCO-08 code from the ILO. AEs = advanced economies; EMs = emerging market economies; ILO = International Labour Organization; ISCO = International Standard Classification of Occupations; LICs = low-income countries.

Limited STEM skills and managerial roles, and low presence in manual skills are among the factors associated with the gender gap in green jobs. For five countries for which data are available, we perform a decomposition exercise to assess the importance of these factors, for which green occupations are divided into five categories: (1) STEM and non-managerial, (2) managerial in STEM, (3) managerial occupations that are not STEM, (4) manual jobs, and (5) all other green occupations. STEM occupations are classified by referencing the O*NET (2021) list, which categorizes occupations based on work performed and, in some cases, the necessary skills, education, and/or training. STEM occupations fall into four domains: (1) life and physical science, engineering, mathematics, and information technology occupations; (2) social science occupations; (3) architecture occupations; and (4) health occupations. Evidence suggests the following (Figure 5):

- Among college-educated workers, more than half of the employment gender gap is associated with a gender gap in STEM occupations. In nations such as Brazil, Colombia, the United Kingdom, and the United States, occupations within the STEM field relate to approximately half of the observed disparity in green employment between college-educated men and women, and to about a quarter of the gap in South Africa.
- Gender gaps in managerial occupations also account for a large share of the green employment gender gap. In South Africa, the disparity between men and women in managerial jobs accounts for 56 percent of the gap in green jobs. Similarly, in the United Kingdom, the gap in managerial occupations contributes 39 percent of the overall discrepancy, while in Brazil, Colombia, and the United States, it accounts for about 20 to 25 percent.
- For workers without a college education, while the managerial and STEM gaps also play a role, the gender gap predominantly reflects disparities in manual occupations. In Brazil, Colombia, and South Africa, this factor accounts for nearly 80 percent of the gender green employment gap among those without higher education. In the United States and the United Kingdom, the influence of manual job disparities remains significant but varies, explaining about 70 percent and 50 percent of the employment gap, respectively.

Figure 5. Gender Green Employment Gap Decomposition (Selected Countries)



Sources: American Community Survey (United States, 2019); Gran Encuesta Integrada de Hogares (Colombia, 2022); Labor Force Survey (United Kingdom, 2022); Labor Market Dynamics in South Africa Survey (South Africa, 2019); Pesquisa Nacional por Amostra de Domicilios Continua (Brazil, 2022); and IMF staff calculations.
Note: The figure decomposes the employment gap between men and women in green jobs by employment in STEM, STEM and managerial, managerial, other green manual, and other green non-manual occupations. Panel 1 examines the gap among college-educated workers, while panel 2 looks at those without a college degree. Data labels in the figure use International Organization for Standardization (ISO) country codes. STEM = science, technology, engineering, and mathematics.

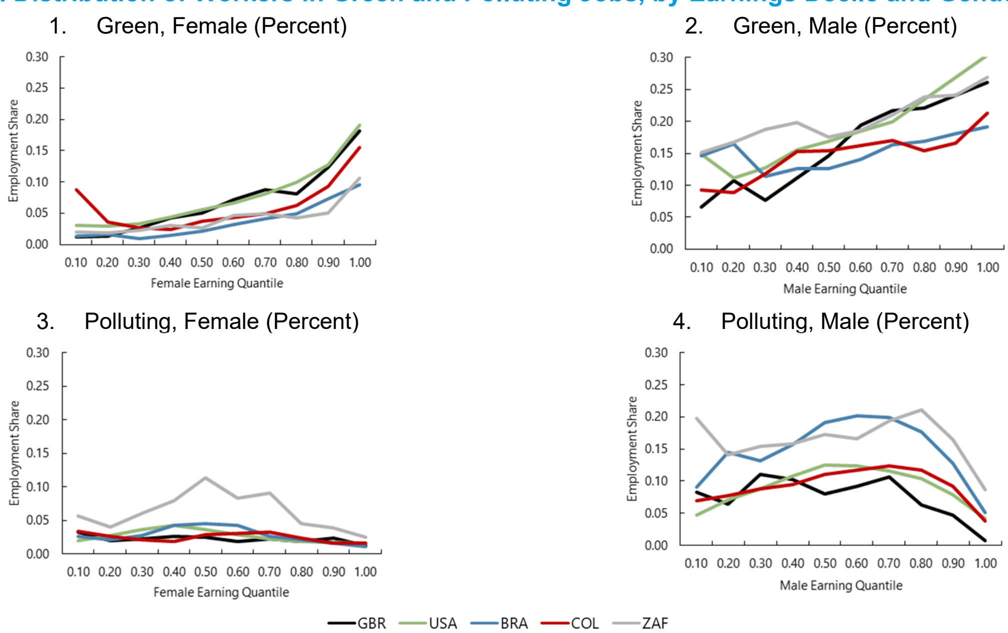
Incorporating more women into green jobs would not only make the green transition more inclusive but could also help enhance the effectiveness of green policies. The underrepresentation of women in green jobs risks contributing further to gender disparities in the labor market, as green jobs become a growing source of employment. Removing obstacles to their participation in these jobs, either through STEM or managerial occupations, will be important to ensure a greater inclusiveness of the green transition. In addition, later sections of this study show that increasing female participation in green jobs could significantly amplify the impact and efficiency of environmental policies, supporting simultaneously a more sustainable and equitable economic future.

Meanwhile, polluting jobs exhibit a gender imbalance like that found in green jobs in AEs—putting men in these countries at greater risk from future declines in the demand for these jobs—while in EMs and LICs the distribution of polluting jobs is less unbalanced (Figure 4). In AEs, men significantly outnumber women in polluting jobs that account for 13.7 percent of their employment and only 3 percent of women's employment. This disparity is also evident in EMs, although less pronounced. In EMs, 10.2 percent of men work in polluting jobs compared to 7.6 percent of women. In LICs, however, the figures are 8.6 percent for men versus 10.7 percent for women. About 70 percent of polluting jobs are held by men globally. The majority of these jobs are in manual occupations like craft and trades, plant and machine operators, and elementary occupations (Figure 3).

Green and Polluting Job Holders by Income Level

Having looked at the distribution of green and polluting jobs through the occupational and gender lens, we next examine their relationship to earning levels in an effort to ascertain how the shift in labor demand from polluting to green jobs could affect income inequality in the economies undergoing a green transition.

Figure 6. Distribution of Workers in Green and Polluting Jobs, by Earnings Decile and Gender

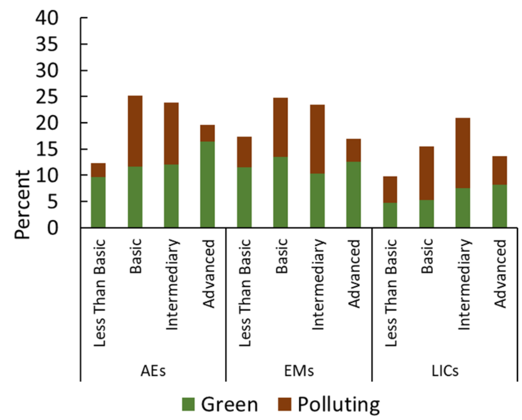


Sources: American Community Survey (United States, 2019); Gran Encuesta Integrada de Hogares (Colombia, 2022); Labor Market Dynamics in South Africa Survey (South Africa, 2019); Labor Force Survey (United Kingdom, 2022); Pesquisa Nacional por Amostra de Domicilios Continua (Brazil, 2022); and IMF staff calculations.
Note: The figure shows the employment share of workers in green (panels 1 and 2) and polluting (panels 3 and 4) occupations by earnings deciles, gender, and country. The earnings decile is conditional on gender.

Green jobs are predominantly found among the higher-earning segments of the workforce in all countries here considered (Figure 6). In both the United Kingdom and the United States, more than 25 percent of male workers and 20 percent of female workers within the top earnings decile are employed in green jobs. This is notable considering that green jobs make up only 12 percent of total employment in these countries, highlighting that green jobs are generally associated with higher earnings. A similar trend is observed in Colombia and South Africa, where green jobs are concentrated at the higher end of the earnings distribution and are more prevalent among men. For the larger sample of AEs in Figure 7, the positive correlation between green jobs and earnings is consistent with the observation that green jobs tend to account for a larger share of employment for workers who have attained higher education. The prevalence of green employment is more similar across education levels in EMs and LICs, reflecting that green jobs also comprise a significant fraction of manual and elementary occupations as discussed previously.

Figure 7. Employment Share, by Education

(Percent)



Sources: ILO calculations based on data from the ILO Harmonized Microdata Repository; and IMF staff calculations.
Note: The figure plots the employment share of green and polluting jobs by education, across AEs, EMs, and LICs. The plots are based on a sample of 98 countries with 25 AEs, 50 Ems, and 23 LICs with available employment data at three-digit ISCO-08 code from the ILO. Advanced = short-cycle tertiary education or above; AEs = advanced economies; Basic = primary or lower secondary education; EMs = emerging market economies; ILO = International Labour Organization; Intermediate = upper secondary or postsecondary nontertiary education; ISCO = International Standard Classification of Occupations; Less than basic = no schooling or early childhood education; LICs = low-income countries.

In contrast to green jobs, polluting jobs are more commonly found among middle-income male workers with basic or intermediary levels of education. This trend is particularly pronounced in Brazil and South Africa, which have the largest share of workers in polluting jobs among the five countries where micro-data is available. Polluting jobs account for 15 to 20 percent of jobs held by middle-class men in Brazil and South Africa, and about 10 percent of those in Colombia, the United Kingdom, and the United States (Figure 6). In the countries here analyzed, the presence of females in polluting jobs is small and concentrated in light manufacturing, garment industries, and food preparation, which are likely to be less immediately affected by the green transition.

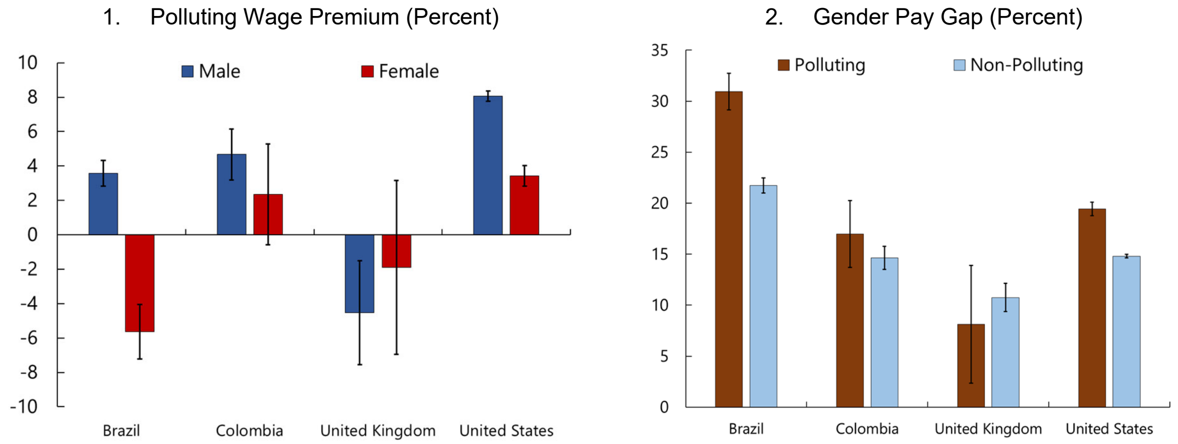
Drawing on the evidence for the five countries in our sample, the green transition could exacerbate income inequality and the hollowing out of the middle class, especially for men. On the one hand, the shift toward a more sustainable economy is likely to increase the number of workers working on green jobs, which are typically in well-paid positions. On the other hand, the green transition is expected to reduce the demand for polluting jobs, predominantly impacting middle- and low-skilled workers. The resulting hollowing out of the middle class would impact more strongly men, who hold a large fraction of the polluting jobs, and could also be more pronounced in other countries where polluting jobs are overall more prevalent. This trend could be eased, however, if polluting sectors could switch to electrification and clean energy–operated machinery, which would reduce the need for reallocation away from these sectors.

Wage Premiums by Gender in Green and Polluting Jobs

Traditionally, polluting jobs have been regarded as “good” jobs. One way of measuring this is by estimating the wage premium they carry (that is, the remuneration that goes above and beyond the level that can be explained by the worker’s characteristics and the type of occupation). Typically, polluting jobs are thought of as carrying a positive wage premium either because they are in sectors with rents (such as extraction of fossil fuels) or in large firms with higher returns to tenure (such as manufacturing). We apply the same wage premium analysis to green jobs to measure their relative attractiveness compared to other jobs in the economy and polluting jobs. Additionally, we estimate the wage premium by gender to shed light on how the gender pay gap may vary between polluting, green, and other jobs and how the green transition may affect it as workers reallocate toward green jobs.

Polluting jobs are associated with a positive wage premium in the countries here considered; however, they are characterized by a more significant gender pay gap than other jobs. A Mincerian wage regression analysis that adjusts for workers' characteristics, such as education, marital status, main occupation group, informality, experience, and age, and for broad sectors of employment is performed for Brazil, Colombia, the United Kingdom, and the United States—the countries for which we have granular data to do the analysis (Figure 8).[9,10] It shows a positive wage premium for men in polluting jobs in Brazil, Colombia, and the United States, ranging from 4 percent in Brazil to 8 percent in the United States, while the United Kingdom experiences a wage penalty. Polluting jobs, however, carry a larger gender pay gap than other jobs in Brazil and the United States, while in Colombia and the United Kingdom, polluting jobs do not significantly impact the gender pay gap.

Figure 8. Polluting Wage Premium and Gender Pay Gap (Selected Countries)



Sources: American Community Survey (United States, 2019); Gran Encuesta Integrada de Hogares (Colombia, 2022); Labor Force Survey (United Kingdom, 2022); Pesquisa Nacional por Amostra de Domicilios Continua (Brazil, 2022); and IMF staff calculations.
Note: The figure shows the polluting wage premium and the gender pay gap for Brazil, Colombia, the United Kingdom, and the United States. More details about the econometric specification can be found in Alexander and others (2024).

Green jobs are also associated with a positive wage premium over non-green jobs, but unlike for polluting jobs, this premium is higher for women (Figure 9). The premium ranges from 4 percent in Colombia to nearly 16 percent in the United Kingdom. These findings align with previous research indicating a green wage premium in AEs (Bluedorn and others 2023; OECD 2023a), and importantly, suggest that this feature could also hold in EMs.[11] Interestingly, the green wage premium is higher for women. In all countries in the sample, women enjoy a larger green wage premium compared to men, with the disparity most pronounced in Colombia and the

[9] The wage dynamic analysis does not consider South Africa because of the well-known problem with the earnings data from the Labor Market Dynamics Survey documented in Köhler and Bhorat (2023).

[10] The analyses on the return of green jobs and the gender pay gap suffer from well-known selection and omitted variable biases since they are restricted to workers who participate in the labor force.

[11] More details about the analysis and econometric specification can be found in Alexander and others (2024). A robustness check shows that the results for the green wage premium remain robust and increase in magnitude when more granular sectoral controls are added. However, these controls reduce the estimated wage premium on polluting jobs since polluting jobs are defined based on the sector of employment. To ensure a consistent treatment across both types of jobs, we use less granular sectoral controls.

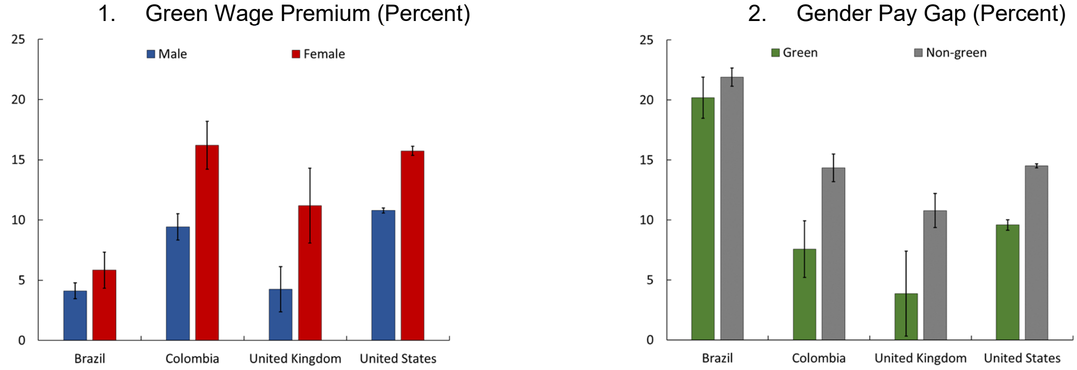
United Kingdom, where the differential reaches nearly 8 percentage points. In addition, it is also important to note that the size of the green wage premiums outweighs the polluting wage premiums across genders and countries, highlighting the benefits of green jobs over polluting jobs.

This significant green wage premium for women leads to a reduced gender pay gap for green jobs and could improve gender pay equality. The study observes a persistent gender pay gap across all sampled countries, consistent with findings from the OECD (2023b). The gap varies significantly, from nearly 20 percent in Brazil to less than 5 percent in the United Kingdom. Notably, across all countries in the study, the gender pay gap is on average 30 percent narrower within green jobs compared to the broader economy. Current pay levels therefore indicate that green jobs are well-paying jobs for women. The static nature of the analysis, however, does not allow to foresee the evolution of the green wage premiums, which will greatly depend on the green labor demand and supply dynamics. As more workers acquire the skills needed to work in green jobs, it is possible that the green premium (including the higher premium for women) declines. However, at their current levels, these premiums provide strong incentives to invest in the skills required for these jobs.

The existence of a green wage premium suggests that labor supply may not be meeting the growing labor demand for workers with green skills.[12] Multiple barriers could exist, such as a current undersupply of workers with STEM education—as educational outcomes take years to adjust, or increased demand for STEM workers for AI development and integration. The imbalance between demand and supply also seems larger for women than men. Moreover, green jobs may carry larger labor productivity, as they could be concentrated in younger and more technologically advanced firms, leading to a higher wage premium in the short term. This would last until workers reallocate. More research is needed to understand the main reason behind the larger green wage premium, especially for women, whether this reflects potentially lower preferences of women for STEM and green jobs, structural differences in the organizational culture of green firms that put a higher premium on gender equity, or expected productivity benefits from increasing gender diversity in sectors where women are underrepresented. We discuss policies to address constraints on the supply of workers for the green economy in the next section.

Figure 9. Green Wage Premium and Gender Pay Gap (Selected Countries)

1. Green Wage Premium (Percent) 2. Gender Pay Gap (Percent)



Sources: American Community Survey (United States, 2019); Gran Encuesta Integrada de Hogares (Colombia, 2022); Labor Force Survey (United Kingdom, 2022); Pesquisa Nacional por Amostra de Domicilios Continua (Brazil, 2022); and IMF staff calculations.
Note: The figure shows the green wage premium and the gender pay gap for Brazil, Colombia, the United Kingdom, and the United States. More details about the econometric specification can be found in Alexander and others (2024)

[12] While it is possible that the green wage premium may also reflect rents in the green sector, there is no clear evidence supporting this notion.

STEM and Gender Equality

This section discusses how policies can help close gender disparities in STEM fields and more broadly in economic participation. By doing so, policies would not only make the green transition more inclusive, but they could also facilitate it, through increasing the overall supply of STEM human capital and enhancing the productivity and innovativeness of the labor force. With an eye to the future, we also examine in Box 1 how AI—a new form of technology and capital—is likely to impact workers in green jobs and contribute to the green transition, either by enhancing the productivity of workers in green jobs or by replacing them to perform tasks more productively. The analysis in the box finds that workers in green jobs, particularly the highly educated and women, are largely poised to benefit from AI advancements while the threat of displacement is modest.

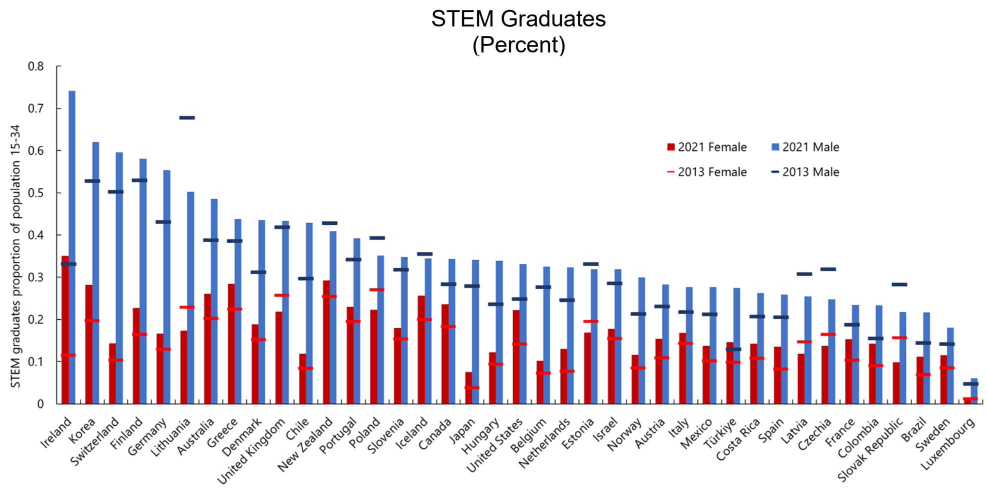
STEM Human Capital

Green jobs often require a STEM degree, presenting a significant barrier for women to benefit from these opportunities. The gender gap in green jobs is likely a reflection of the broader issue of gender disparity in STEM education. Although girls generally achieve higher overall educational attainment compared to boys (Wiese and Culot 2022; Devereux and others 2022), the gap in STEM fields not only persists but has, in many cases, widened (Figure 10). This is largely due to a greater increase in STEM graduations among boys compared to girls. However, there are notable exceptions where the gap has narrowed, particularly in Iceland, Korea, and New Zealand, where the rate of girls graduating in STEM has increased more rapidly than that of boys.

Significant progress in increasing girls' graduation rates in STEM is possible with targeted policies, as observed, for example, in Ireland and Korea. In Ireland, the percentage of girls graduating in STEM fields relative to the population aged 15 to 35 increased from 0.1 percent to nearly 0.3 percent, and in Korea, from 0.2 percent to almost 0.3 percent in a relatively short period of time. These increases reflect targeted policies to increase STEM graduates and address STEM gender gaps. Box 2 further discusses Ireland's strategy to enhance STEM education, which integrates STEM subjects across all educational levels, with a focus on early education, especially for girls. This approach includes gender-focused curriculum and specialized training for educators. Additionally, strategic collaborations between public and private sectors aim to motivate girls toward STEM careers. A concerted effort to recognize and fairly compensate educators helps attract and keep good STEM educators. Additionally, Annex 5—focusing on the United States—shows that women with a STEM background have a very high labor force participation rate, indicating that this specialization offers good and stable careers.

Boosting women's involvement in STEM could help increase the overall supply of STEM human capital, which is a key resource to facilitate the green transition. There is a wide variation in the percentage of STEM graduates across countries. Greece, Ireland, and New Zealand have the highest percentage of female STEM graduates at about 0.3 percent, while Japan and Luxembourg are at the opposite end with less than 0.1 percent. For males, Ireland, Korea, and Switzerland lead with STEM graduate shares of 0.6 to 0.7 percent, while Luxembourg and Sweden have the lowest shares below 0.15 percent. Over 60 percent of occupations classified as green are in STEM fields (Alexander and others 2024), and female labor participation among women with a STEM background is extremely high, as discussed in Box 2. Consequently, bringing more women into green jobs without increasing the number of women graduating in STEM fields would be insufficient. It would merely shift the gender disparity from green jobs to other STEM-related jobs. In addition, AI may also put pressure on the availability of STEM graduates for the green transition, which further underscores the need for an increase in STEM graduates. Therefore, as we will show in the next section, a higher supply of STEM graduates could help boost GHG mitigation, green innovation, and the share of green employment.

Figure 10. Skills Gaps and Training Needs



Sources: OECD (2021); and IMF staff calculations.
Note: The figure calculates STEM graduates as a sum of bachelor graduates aged 15 to 34 in natural sciences, mathematics, and statistics; information and communication technologies; and engineering, manufacturing, and construction divided by the total population aged 15 to 34. Brazil measures use data from 2013 and 2018. STEM = science, technology, engineering, and mathematics.

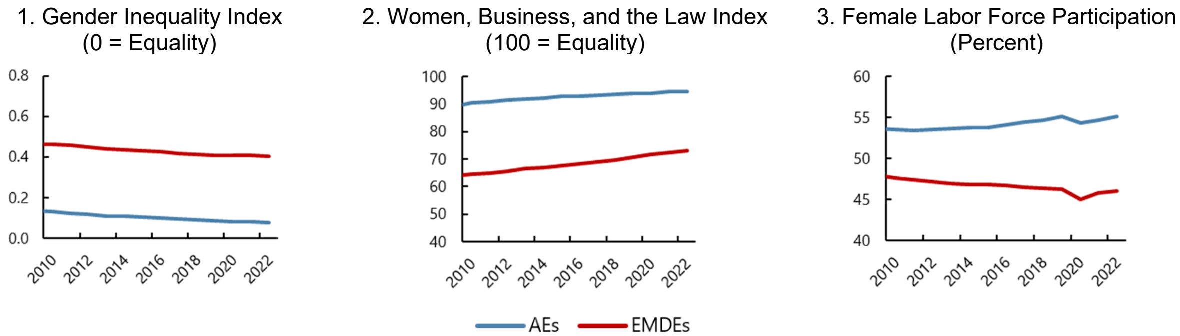
Gender Equality

Despite notable progress, women continue to face obstacles to participation in economic activity. In AEs and EMDEs, there has been a notable increase in gender equality in health, financial access, labor market opportunities, and legal rights (Figure 11). Many factors have contributed to the increase in female labor force participation in AEs and some EMs, including the increase in access to childcare, the reduction in the secondary earner tax penalty, and recently the increase in labor market flexibility and remote work brought about by the pandemic.[13,14] Yet challenges persist. Women's participation in the labor market remains below that of men and has even declined over the last decade in EMDEs (Figure 11). Additionally, women still bear a disproportionate burden of unpaid care and housework, which challenges their participation in the workforce, particularly after becoming mothers (Charmes 2019; Goldin 2014). Factors such as lower employment rates, fewer working hours, and significant labor market segregation also contribute to women earning lower wages than men, disincentivizing their participation (OECD 2023b). Furthermore, men significantly outnumber them in senior leadership jobs, where women hold less than 30 percent of middle and senior management positions (World Economic Forum 2023). In EMDEs, four out of five new jobs for women are in the informal economy, compared to two out of three for men (ILO 2023), and cultural and social norms such as child marriage, gender-based violence, and high adolescent fertility rates can also act as barriers to women's economic participation (Jayachandran 2021).

[13] Asai and others (2023) find that increases in childcare and education, active labor market programs, and unemployment benefits help encourage women's labor force participation in Organisation for Economic Co-operation and Development countries.

[14] See Harrington and Kahn (2023) and Ji and others (2024) for a discussion about the potential impact of remote work on women's labor supply.

Figure 11. Female Labor Force Participation and Opportunities



Sources: ILO (2022); IMF, Gender Data Hub; UNDP (2022); World Bank (2022); and IMF staff calculations.
Note: The Gender Inequality Index is a composite measure of gender inequality, incorporating three dimensions: reproductive health, empowerment, and the labor market. Female labor force participation rate uses the modeled ILO estimate for those aged 15 and older. Women, business, and the law is an annual study that compares laws on gender equality in mobility, workplace, pay, marriage, parenthood, entrepreneurship, assets, and pension across 190 countries. AEs = advanced economies; EMDEs = emerging markets and developing economies; ILO = International Labour Organization.

Increasing women's participation and success in the labor force could support the green transition in multiple ways. Evidence suggests that women tend to be more climate-conscious than men (McCright 2010; Franzen and Vogl 2013; Clayton and others 2023), which can lead to more environmentally friendly decision making in various sectors. Studies have shown that a higher share of female managers within firms results in a larger decline in carbon dioxide emissions (Altunbas and others 2022), and female-led firms achieve significantly higher environmental, social, and governmental scores (European Investment Fund 2022). Additionally, banks with gender-diverse boards are more likely to lend to green companies and reduce loans to high-pollution firms (Gambacorta and others 2022). By reducing barriers hindering women's full economic participation, we can also improve talent allocation and achieve significant productivity gains (Hsieh and others 2019). A gender-balanced workforce has been shown to leverage the complementary skills of men and women, further boosting productivity (Ostry and others 2018). The return from complementarity would be particularly large in green employment because it is currently very skewed toward men. Thus, promoting gender equality is ultimately also a strategic approach to fostering a sustainable and efficient green economy.

To facilitate a more inclusive and effective green transition, it is essential to implement deliberate policy actions that remove barriers to women's participation in the economy. Key measures include enhancing access to childcare services, parental leave, and remote work to support working mothers and maintain their connection to the workforce (IMF 2022b). Combating discrimination through the robust implementation and enforcement of anti-discrimination laws is essential (OECD 2023b). Additionally, revising direct and indirect biases in tax policies that penalize secondary earners, predominantly women, and create disincentives to work has been found to be crucial in boosting female labor force participation (Bick and Fuchs-Schündeln 2018; Fabrizio et al. 2020). Fiscal policies present a significant opportunity to advance gender equality. For example, gender budgeting integrates a gender perspective into fiscal planning to address the varying effects of government budgets on different genders (Alonso-Albarran and others 2021). Expanding opportunities for women to secure formal employment, including increased access to finance, is also necessary (UN Women and African Development Bank 2021; World Bank 2021; IMF 2022a). Finally, legal framework reforms to tackle discrimination remain essential to level the playing field. These policy actions not only promote gender equality but can also contribute to a more dynamic and resilient economy capable of meeting the challenges of the green transition.

Also, policies must prevent lower-skilled workers, particularly those impacted by the decline of polluting sectors, from being left behind during the green transition. The shift toward greener industries presents notable challenges for many workers traditionally employed in polluting sectors. Although various government initiatives have been implemented to support these workers through retraining programs, enhanced pension benefits, and reallocation efforts, the transition remains difficult for regions reliant on such industries. Studies indicate that the loss of a single coal mining job can result in the loss of up to four additional jobs in related sectors, underscoring the significant ripple effects in regions where coal mining is a critical economic activity, often marked by higher poverty rates (OECD 2021). Comprehensive policy frameworks that support economic diversification and enhance skill development are crucial to facilitate smoother transitions for these workers (World Bank 2022; OECD 2023a). Thus far, many policies have primarily focused on miners, with insufficient attention to workers in the broader coal supply chain and those in coal-dependent communities (World Bank 2020). Notable initiatives, such as the Westhaven arrangement in The Netherlands, where stakeholders and social partners designed together a comprehensive plan to guide the 1,500 employees who lost their jobs as they sought new jobs and tried to avoid unemployment, have demonstrated effective strategies to mitigate the impact of coal mining on local economies (OECD 2023a).

Helping the Transition via Labor Markets

Closing gender gaps in STEM education and improving gender equality in economic participation may not be only good for inclusiveness. They may also facilitate the green transition and reduce its economic cost. To examine this possibility more formally, we first employ empirical analysis to delve into the interactions between labor market characteristics and green policies, and thereafter develop a general equilibrium model that highlights the key mechanisms through which labor market features could affect the efficacy of green policies and their broader welfare implications for society.

Green Policies' Effectiveness and Labor Markets

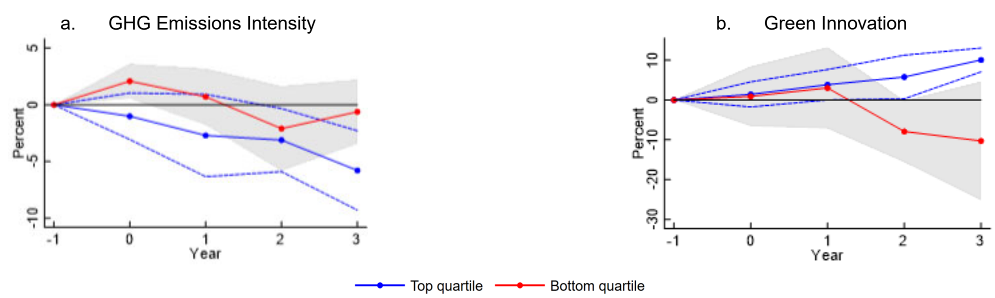
This analysis investigates the impact of major climate policy initiatives on emissions, in particular energy taxes, exploring their interaction with labor market conditions. To assess the significance of labor market conditions on the effectiveness of climate policy, an impulse response analysis using the Jordà (2005) local projections method is conducted. It considers three dimensions of labor market conditions: (1) the share of graduates with a STEM degree, (2) an indicator that measures the pace of legal reforms to create equal economic opportunities for women ("women, business, and the law"), and (3) a broader indicator of gender equality. To control for possible omitted variable biases and isolate the impact of climate policies and labor market conditions only, the analysis controls for the quality of institutions (in the areas of governance, business regulation, and external sector reforms) and the share of workers with tertiary education and their interaction with the climate policy variable, in addition to more standard controls such as past economic growth, GDP per capita, year, and country fixed effects. Data analysis from 108 countries shows that energy taxes—comprising taxes on transport and energy products, as well as direct GHG emission taxes—are more effective at reducing the GHG emission intensity of GDP in countries with favorable labor market conditions (that is, countries at the top quartile).[15] The analysis was also conducted using the climate policy count, which documents the number of climate policies and regulations in the country. Similar results were found, as shown in Annex Figure 3.3.

Figure 12. Impact of Energy Taxes on GHG Emissions Intensity of GDP

1. Conditional on STEM Graduates and Its Transmission Channel via Green Innovation

2. Conditional on Gender Equality and Its Transmission Channel via Green Employment

3. Conditional on Women, Business, and the Law and Its Transmission Channel via Green Innovation



Sources: Fraser Institute; Hasna and others (2023); ILO calculations based on data from the ILO Harmonized Microdata Repository; IMF, Climate Change Indicators Dashboard; UN Development Programme; World Bank; and IMF staff calculations.
Note: *t* = 0 is the year of the shock. The lines denote the response to a major historical change in the energy-tax-revenues-to-GDP ratio (one standard deviation, or 1 percentage point of GDP). The dashed lines and shaded bands indicate the 90 percent confidence interval. The analysis is based on a sample of 35 AEs and 73 EMDEs from 2003 to 2020. The plots show the impact of energy tax conditional on gaps in labor market conditions. The index of woman, business, and the law analyzes not only the pace of legal reforms to create equal economic opportunities for women, but also countries' efforts to implement those laws. The other two labor market condition indicators show the share of graduates from STEM and gender equality in three dimensions including (1) reproductive health, (2) empowerment, and (3) the labor market. The energy tax shock is measured as the change in the residual term from an equation that regresses the energy tax revenue–to-GDP ratio on current and past growth (one and two lags). See Annex 3 for methodological details. Green innovation is measured as the number of green patent filings, and green employment is the share of green jobs. One caveat when interpreting the results on green employment is that the green job data coverage in EMDEs is limited. The test for the difference in response between top and bottom reformers is also provided in Annex Figure 3.4. AEs = advanced economies; EMDEs = emerging market and developing economies; GHG = greenhouse gas; ILO = International Labour Organization; STEM = science, technology, engineering, and mathematics.

Countries with a robust share of STEM graduates appear to experience more pronounced environmental benefits from energy tax increases (Figure 12). Specifically, a 1 percentage point increase in the cyclically

[15]Countries are categorized into three groups each year: bottom 25 percent, top 25 percent, and middle 50 percent based on reform levels. For more details, see Annex 3. Though our identification method helps broaden cross-country coverage, the shock identified from the cyclically adjusted tax revenue may suffer from exogeneity and fiscal foresight issues.

adjusted energy tax revenues relative to GDP is associated with approximately a 3 percent reduction in GHG emissions intensity of GDP in countries with a high proportion of STEM graduates. The effect is statistically significantly different from zero, starting in year 1. In contrast, in nations with fewer STEM graduates, the impact of the same tax increase is negligible and not significantly different from zero as it is very imprecisely estimated. The difference between these two effects is statistically significant in year 1 and year 3, as shown in Annex Figure 3.4. STEM graduates support the reduction of emissions by stimulating green innovation as shown in Figure 12, panel 1b, and to a lesser extent employment as shown in Annex Figure 3.2.[16]

Gender equality in economic participation also correlates with greater effectiveness of green policies. Nations scoring well on the "women, business, and the law" measure or on the broader "gender equality" indicator experience a statistically significant similar 6 percent reduction in GHG emission intensity three years post-reform when energy taxes are increased. However, the effect of energy taxes on the emission intensity is smaller and not significantly different from zero in countries with poor performance on gender equality measures. Moreover, the difference between the two estimates is significant at period 3 for the "gender equality" indicator and at periods 0 and 3 for the "women, business, and the law" measure. High performance on the "gender equality" indicator correlates with a stronger increase in green employment in the medium term, supporting decarbonization efforts, while strong scores in "women, business, and the law" are associated with a stronger response of green innovation but not of green employment.

Importantly, the impact of energy taxes on output is less negative or statistically insignificant in countries performing well across these labor market indicators, underscoring the broader economic benefits of aligning labor market characteristics with green policy objectives.[17] A greater STEM workforce can reduce the economic cost of the transition by supporting green innovation, as shown in Annex Figure 3.2. Green innovation boosts economic output over the medium term, which mitigates potential costs from climate policies (Hasna and others 2023). Moreover, a larger share of workers with STEM degrees, and more gender equality, can support the creation of jobs in green occupations, stimulating employment and reducing the cost of the green transition. While this analysis highlights potential channels through which STEM education and gender balance enhance the effectiveness of green policies, additional research could help investigate other possible channels and refine the identification strategy.

Welfare Implication of the Green Transition

A multisector general equilibrium model was developed to rationalize the empirical findings observed in the analysis. In this model, a final good is produced using inputs from green, polluting, and neutral intermediary sectors. Green and polluting goods are modeled to have a high degree of substitutability, whereas neutral goods are complementary to both green and polluting goods. Intermediary goods production utilizes both STEM and non-STEM labor from men and women, except for polluting intermediary goods, which predominantly rely on men's labor. Green intermediary production is more intense in STEM labor than neutral and polluting intermediary production. Labor inputs supplied by both men and women are considered imperfect

[16] Additional robustness checks controlling for changes in public perception about climate change were also performed, yielding similar results. However, due to the limited sample of countries with these controls, they were not included in the note. In addition, to check whether the results were driven by AEs or EMDEs, we performed a similar analysis to the one in Figure 12, focusing separately on AEs and EMDEs. We found that the results for AEs and gender equality in EMDEs are quite robust. However, the results for STEM in EMDEs were less robust due to a lack of data on STEM workers in EMDEs, leading to a very limited sample.

[17] Bluedorn and others (2023) show that flexible labor markets help reallocate workers to green jobs, while coordinated labor markets with collective bargaining reduce the pollution intensity of employment.

substitutes.[18] Men and women maximize consumption, and they decide how many hours of labor they provide for different sectors. STEM and non-STEM workers differ on their labor productivity, and men and women as well; the economywide share of STEM workers is exogenous. The model is calibrated to the United States and replicates the share of men and women with STEM education in each sector of the economy, the gender pay gap in green and non-green jobs, and the macroeconomic importance of each economic sector.[19]

The model predicts that the impact on GDP and welfare of reducing emissions would be smaller in countries with a larger share of workers in STEM and a more equal distribution of STEM jobs between men and women. Four scenarios are simulated to estimate the impact of labor market conditions on the effectiveness of climate policies in Figure 13. The share of STEM workers is kept constant in each scenario, allowing us to measure solely the interaction between climate policies and STEM workers. The four scenarios are (1) a scenario with the current share of population in STEM, (2) a scenario where the share of male STEM workers is 10 percentage points higher, (3) a scenario where the share of female STEM workers is 10 percentage points higher, and (4) a scenario where the share of male and female STEM workers is each 5 percentage points higher. A carbon tax is imposed to reduce emissions from the energy sector by 50 percent.[20]

Model simulations indicate that a larger share of workers in STEM and a greater involvement of women in STEM correlate with lower economic costs of emission reductions by more than 20 percent (Figure 13, panel 1). A large share of workers in STEM would reduce the cost of climate policies because STEM labor is a key input in the production of green goods. The green sector employs more STEM workers than the polluting sector. As a result, when a carbon tax is imposed, changing the relative price between polluting and green goods, an economy with a relatively larger share of STEM workers would suffer less from distortive taxes because it is more abundant in the input needed to produce green goods (STEM workers). This effect suggests that the needed carbon tax would be lower in an economy with more STEM workers to generate the same decline in emissions. When comparing the four scenarios, the economic impact on output is lowest—just 0.3 percent—when there is a larger share of women in STEM. This outcome is attributed to a more ample supply of STEM labor and a reduction of the gender gap in STEM. Increasing the proportion of women in STEM would lead to a more balanced distribution between men and women, enhancing the complementarity of their labor. Consequently, incorporating more women into STEM would be beneficial, including by requiring a smaller increase in the carbon tax to achieve the same emission reduction. The second least costly scenario for emission reduction occurs when the increase in STEM is equally split between men and women, while the least effective scenario involves no increase in STEM education.[21]

[18] Ostry and others (2018) find that male and female labor are imperfect substitutes in production, leading to economic benefits from increased gender diversity. Their analysis highlights two main mechanisms: enhanced gender diversity and better talent allocation from a larger workforce pool.

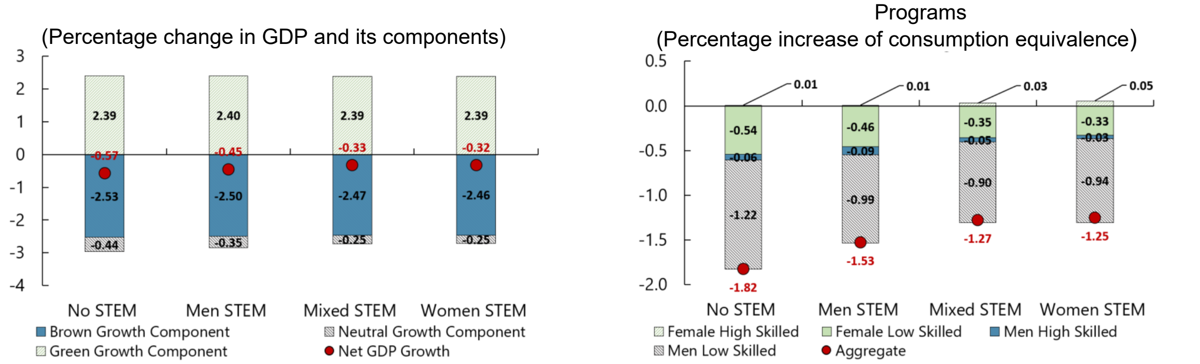
[19] In the model, men and women differ on their labor productivity, and the difference in labor productivity is calibrated to match the gender pay gap observed in the data. More details about the model and calibration are provided in Annex 4.

[20] We abstract from the cost of educating workers in STEM because the share of workers in STEM is kept constant between steady states; thus, the cost of education is not factored into the results. However, we have also simulated a combined scenario where we increase the share of workers in STEM by 10 percent (from 8 to 9 percentage points) over 10 years and incorporate a ½ percent of GDP cost to educating students in STEM (which is on the high side). In this scenario, the increase in the STEM workforce and the carbon tax together generate an increase in output because STEM workers have higher labor productivity than non-STEM workers. The increase in the share of STEM workers more than compensates for the decline in economic activity generated by the carbon tax. The model also abstracts from other important ingredients for a successful climate reform strategy, including broad stakeholder engagement, a comprehensive communications strategy, and a robust mitigation approach. For a more in-depth discussion about the design of climate policies, see IMF (2023).

[21] The women in STEM scenario and the mixed STEM scenario deliver similar results for GDP, because the additional complementarity gains are offset by the unexplained factors underlying the gender wage gap.

Figure 13. The Interaction between Green Policies and Labor Market

1. Polluting Tax Effects on GDP under STEM Programs
2. Polluting Tax Effects on Welfare Gains under STEM Programs



Source: IMF staff simulation.
Note: The figure describes the effects on GDP (panel 1) and welfare (panel 2) of targeting a reduction in emissions from the energy sector by 50 percent by implementing a carbon tax. Four scenarios are simulated to estimate the impact of labor market on the green transition: (1) business as usual, (2) a 10 percentage point higher share of men in STEM, (3) a 10 percentage point higher share of women in STEM, and (4) a 5 percentage point higher share of men and women in STEM. In panel 1, net GDP percent change is depicted by the red dot and percentage number, while the blue, grey, and green bars describe the percent change of the brown, neutral, and green components of GDP, respectively. In panel 2, aggregate welfare gain is depicted by the red dot and percentage number, while the green, green, blue, and grey describe the welfare gains components of gender and skill. Welfare gains are constructed by computing the consumption equivalence percentage change of the environment with the carbon tax policy versus its respective baseline. STEM = science, technology, engineering, and mathematics.

The welfare effects of the transition seem to be also less negative when women are more actively engaged in the green economy but vary across groups (Figure 13, panel 2). Although the green transition results in welfare declines when the environmental benefits of the transition for consumers are not considered,[22] simulations suggest that the welfare effects are less negative by more than 0.5 percentage point when there is a higher presence of women in the green sector because the economy experiences less output loss during the transition, as shown previously. Welfare losses are concentrated among men in non-STEM jobs who are adversely affected by the carbon tax in the polluting sector. Women in non-STEM occupations face the second most negative impact due to increased competition for non-STEM jobs. Men and women in STEM occupations experience welfare gains because the green sector expansion increases the demand for STEM workers. The concentration of welfare losses among workers in polluting jobs underscores the need for targeted support for these workers, ensuring that the transition benefits all workers and helping to reduce resistance against climate policies.[23]

Conclusion

A sustainable future hinges on significantly expanding the workforce in green jobs globally—economies with a robust supply of STEM-educated workers and more equal gender treatment seem better positioned to transition to a green economy faster and at a lower cost. To foster a more inclusive green transition, supporting STEM education is imperative. STEM degrees are crucial not only for the green transition but also for driving technological progress and economic growth. Experiences from countries like Ireland, which has significantly increased STEM graduation rates in a relatively short period, as detailed in Box 2, demonstrate that targeted education policies can be effective and desirable despite their short-term costs. Enhancing both boys' and girls'

[22] Incorporating the environmental benefits of the transition will change the welfare impact. However, it will not affect the order since all experiments generate the same reduction in emissions, which ultimately generates the same environmental benefit.
[23] For example, IMF (2022a) finds that the revenue from carbon taxes is more than enough to compensate low-skilled workers negatively impacted by the policy.

STEM education requires a comprehensive approach that goes beyond improving math scores in school to include increasing exposure to STEM activities from an early age, fostering mentorship programs, and encouraging public-private partnerships. Through partnerships, companies can contribute resources, expertise, and innovation to support government initiatives.

Despite a significant green wage premium, women remain underrepresented in green occupations. This gender disparity appears to be mostly driven by gender gaps in STEM and managerial positions in AEs and to a certain extent in emerging markets, where also gender inequality in manual jobs is a relevant factor. Reducing gender gaps in STEM education is key. AI holds potential to support the green transition, including by enhancing productivity in green jobs. However, AI's development could also compete for the talents needed to advance the green transition, particularly among STEM professionals, underscoring the importance of ensuring a sufficient supply of STEM workers.

The inherent job flexibility and remote work opportunities in STEM fields are already attracting more women to these sectors, as discussed in Annex 5. Nonetheless, sustained government action and recognition from the private sector are crucial to maintaining this momentum. Specific measures could include supporting flexible work arrangements, mentorship, and actively promoting gender diversity in hiring and promotions within the green sector. These policies can be particularly beneficial in EMDEs that have historically suffered from brain drain. By promoting a more favorable work environment, these countries would be better positioned to retain highly educated workers, reducing the exodus of talent and enhancing domestic economic growth.

Beyond STEM-specific barriers, deliberate policy action to remove barriers to women's participation in the economy is key to facilitate a more inclusive and effective green transition. Measures should include enhancing access to childcare services and parental leave to support working mothers. When governments face limited fiscal space, they should prioritize measures with high net benefits—such as investments in education and childcare—even if the benefits materialize only over time. Explaining them clearly can help reap the value of the benefits both upfront and over time (such as through higher expected GDP, lower debt, and better credit ratings). The use of gender budgeting can also help increase the efficiency of the allocation and use of resources. Furthermore, combating discrimination is crucial; this can be achieved through the robust implementation and enforcement of anti-discrimination laws. Additionally, revising direct and indirect biases in tax policies that penalize secondary earners, predominantly women, and create disincentives to work, expanding opportunities for women to secure formal employment, and increasing women's access to finance, are vital steps.

In ensuring a just and equitable green transition, it is critical not to overlook the needs of workers employed in polluting jobs. These workers, particularly old ones, often situated in economically vulnerable regions, face significant and often-times long-lasting disruptions as economies pivot away from fossil fuels. Effective policy measures must be implemented to facilitate their transition and minimize economic dislocation. This includes offering robust retraining programs tailored to emerging industries, ensuring access to lifelong learning opportunities, place-based economic diversification investments to create new industries locally, and providing adequate social safety nets to support workers and their families during transitional periods.

Without deliberate policy action, there is a real risk that the green transition could perpetuate existing barriers faced by women in the economy. These barriers include limited access to finance, fewer opportunities in managerial jobs, and systemic discrimination. The green transition presents a unique opportunity to redefine labor relations and build a more inclusive workforce. Policymakers, the private sector, and civil society must seize this moment to craft a fair and equitable path forward.

Box 1. The Role of Artificial Intelligence[1]

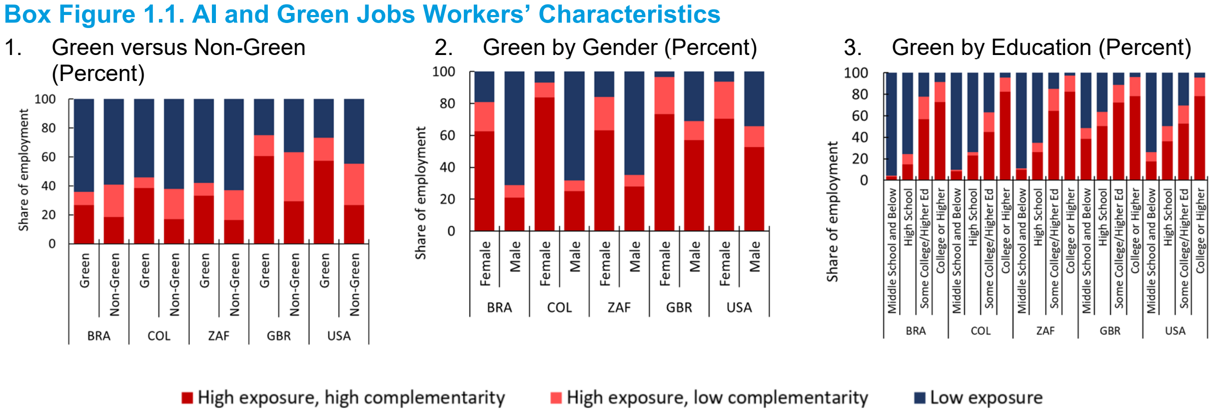
Artificial intelligence (AI) can support the green transition but may pose a risk of displacing workers. We find that workers in green jobs, particularly the highly educated and women, are poised to benefit more from AI advancements.

The impact of AI on green jobs varies significantly. Using Felten, Raj, and Seamans' (2021, 2023) AI "exposure" classification, a job is highly exposed if many of its tasks can be performed by AI. Exposure can translate either in a replacement of the worker by AI if the latter performs the task more productively or an augmentation of worker productivity if human involvement is required. To better assess AI's potential to either augment or replace workers in green jobs, we utilize the complementarity index developed by Pizzinelli and others (2023), which considers social, ethical, and physical contexts, alongside skill levels. This approach categorizes occupations into "high exposure, high complementarity" which are more likely to benefit from AI (for example, environmental engineers), "high exposure, low complementarity" which are at risk of automation (for example, product graders), and "low exposure" which have little to no AI integration potential (for example, sheet metal workers).

Green jobs are poised to benefit from AI. In both advanced economies and emerging markets, nearly 80 percent of AI-exposed green jobs are likely to benefit from AI, compared to less than 50 percent in non-green jobs (Box Figure 1.1). This indicates that green jobs are not only likely to experience a demand boost from environmental policies but also stand to gain from technological advancements with a smaller risk of job displacement.

Women in green jobs appear to have both higher exposure to AI and a larger potential to benefit from it than men, as do college-educated workers compared with less-educated workers (Box Figure 1.1). This is largely due to men occupying more green jobs that involve manual labor with low exposure to AI, which is especially pronounced in emerging markets. Across all countries, over 70 percent of college-educated workers in green jobs could benefit from the high AI complementarity with their occupations. Conversely, the proportion of workers with middle school education employed in green jobs that could benefit from high AI complementarity is notably smaller.

Box Figure 1.1. AI and Green Jobs Workers' Characteristics



Sources: Alexander and others (2024); and IMF staff calculations
Note: Panels 2 and 3 present the employment share of workers in green jobs by gender and education, respectively. Country labels use International Organization for Standardization (ISO) country codes. AI = artificial intelligence.

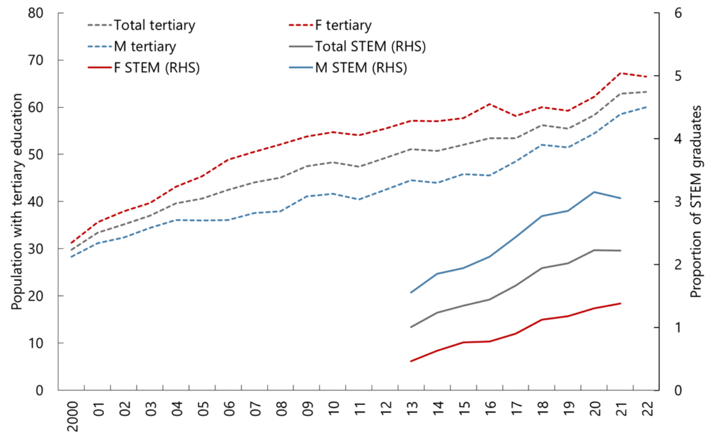
[1]The analysis of AI and the green transition focuses on the impact of AI on green jobs and does not factor in the risk that AI poses to the green transition and environment through high energy and water consumption, nor how fiscal policies can influence AI's impact on inequality, a top discussed in Brollo and others (2024).

Box 2. Irish STEM Policy

Ireland has crafted policies to grow its science, technology, engineering, and mathematics (STEM) workforce to meet the rising demand for STEM and green skills. These policies demonstrate Ireland's potential to adapt STEM education for an expanding workforce catalyzed by technological and scientific shifts.

The Department of Education's STEM Education Policy Statement (2017), along with the "Innovation 2020" strategy, underscores the necessity for support for STEM disciplines through enhanced early education, teacher capacity, and evidence-based STEM education reforms. The ambition is clear: to position Ireland as a frontrunner in STEM education by 2026. Additionally, the STEM Education Implementation Plan articulates a vision to elevate Irish students' STEM education by refining skills, broadening STEM subject choice and career paths, enhancing female participation, increasing career awareness, and guaranteeing ongoing youth engagement in STEM fields.

Box Figure 2.1. Education Trends in Ireland
(Percent)



Sources: OECD (2022); and IMF staff calculations.
Note: Population with tertiary education is defined as those having completed the highest level of education aged 25 to 34 as a percent of those in the same age group. This includes advanced research and vocational programs. STEM graduates as a sum of graduates aged 15 to 34 in natural sciences, mathematics, and statistics; information and communication technologies; and engineering, manufacturing, and construction divided by the total population aged 15 to 34. F = female; M = male; RHS = right scale; STEM = science, technology, engineering, and mathematics.

Remarkably, Ireland has seen a threefold increase in STEM female bachelor graduates and a doubling of male bachelor graduates. Box Figure 2.1 demonstrates the sharp increase in STEM education and the larger positive trend in tertiary education. In comparison with other leading STEM nations, Ireland notably outperforms in mathematics and science scores, ranking within the top three EU countries. Between 2014 and 2021, Ireland produced either the highest or second highest proportion of graduates (per 1,000 graduates) in STEM in the European Union (OECD 2021; Lawlor and Burke 2020).

While significant progress has been made, gender disparities in STEM remain. Gender differences in math skills do not exist at the fourth-grade level and are decreasing in secondary education, with women even surpassing men in science (Seery, Dunbar, and Reid 2022, Lee and others 2022). Efforts to bridge the gender gap in STEM have led to various policy initiatives. For example, the Irish Department of Education established the Gender Balance Advisory Group, a subgroup of the department's STEM Education Implementation Advisory Group. This group has published recommendations aimed at enhancing women's participation in STEM and tackling ongoing challenges. These recommendations shift the focus from altering individual attitudes, beliefs, and behaviors to modifying structures, policies, and representation within STEM fields. Key policy measures include integrating gender considerations in the development and review of the national curriculum, improving access to impactful STEM role models and career guidance, and creating a professional development program for early educators to address gender balance issues (Department of Education 2022). Focused efforts have led to a notable increase in both male and female STEM graduates, surpassing other countries in this aspect. Women also demonstrate higher tertiary education attainment (Box Figure 2.1). However, this progress has not yet resulted in an equitable distribution of male and female STEM graduates.

Nevertheless, the Irish model offers valuable lessons on enhancing STEM education. In recent years, technological and scientific advancements have reshaped the Irish labor market. Ireland is now home to 9 of the top 10 global software companies and 15 of the top 20 medical technology companies (Department of Enterprise, Trade and Employment 2015). In response, the Irish government has ramped up its support for STEM education in the workforce. By capitalizing on its technology-driven economy, Ireland has facilitated and financed STEM education, initiating numerous educational initiatives and collaborations with industry giants such as Accenture, Intel, Google, and Ericsson, aimed at bolstering STEM learning and engagement (Department of Education 2024). Partnerships with the technology industry such as a Microsoft's Dream Space event for primary school students and the Annual Women in STEM summit has also supports women and girls in STEM (Microsoft 2024; Women in STEM 2024).

Ireland's strategy involves embedding STEM across all educational levels. From the early years, children are encouraged to develop math and decision-making skills through daily activities. Ireland has set specific goals, such as increasing female participation in STEM by 4 percent and boosting extracurricular STEM activities by 20 percent. A pivotal shift from focusing solely on content to skills, and from teaching to learning, marks a significant change in educational paradigms. Unlike other STEM education leaders, Ireland stands out for its comprehensive policy framework, interdisciplinary approach, and clear objectives, particularly in its unique focus on early education in preschool and primary school settings (Seery, Dunbar, and Reid 2022).

Teachers are pivotal in Ireland's goal for top-tier STEM education. Recognized and well-compensated (ranking seventh highest in the Organisation for Economic Co-operation and Development), the teaching profession in Ireland is regulated to maintain high standards across all levels of teacher education and professional development. The National Teaching Council regulates professional standards in teaching, covering the entire spectrum of teacher education from entry level to ongoing professional development, which ensures high-quality teaching and aligns educational practices with policy directions (The Teaching Council 2020). Between 2014 and 2018, the number of teachers increased by 13.6 percent across primary and postprimary levels, with over 7,000 additional teachers since 2016, improving the pupil-to-teacher ratio from 15.7 to 14.5 in primary education and from 13.4 to 12.3 in postprimary (Department of Education 2020). Furthermore, efforts are made to deepen teachers' understanding of STEM. For example, the STInt program is designed to connect preservice teachers with STEM industries. This program aims to provide student teachers with real-world STEM experiences and knowledge, enabling them to bring these insights into their classrooms and share them with peers (Hurley and others 2021).

Annex 1. Data

Descriptive Charts

Annex Table 1.1. Data Sources for Stylized Facts

Figures	Sources	Economies
Figure 2. Green and Polluting Jobs	ILO calculations based on data from the ILO Harmonized Microdata Repository	25 AEs and 19 EMDEs
Figure 3. Worker Occupations, by Gender	PNADC and LFS	BRA and GBR
Figure 4. Employment Share, by Gender	ILO calculations based on data from the ILO Harmonized Microdata Repository	25 AEs, 50 Ems, and 23 LICs
Figure 5. Gender Green Employment Gap Decomposition	ACS, GEIH, LFS, LMD, and PNADC	BRA, COL, GBR, USA, ZAF
Figure 6. Distribution of Workers in Green and Polluting Jobs, by Earnings Decile and Gender	ACS, GEIH, LMD, LFS, and PNADC	BRA, COL, GBR, USA, ZAF
Figure 7. Employment Share, by Education	ILO calculations based on data from the ILO Harmonized Microdata Repository	25 AEs, 50 Ems, and 23 LICs
Figure 10. Skills Gaps and Training Needs	OECD	OECD 38 and Brazil
Figure 11. Female Labor Force Participation and Opportunities	IMF Gender Data Hub, UNDP, ILO, and World Bank	190 countries
Box Figure 1.1. AI and Green Jobs Workers' Characteristics	Alexander and others (2024)	BRA, COL, ZAF, GBR, USA
Box Figure 2.1. Education Trends in Ireland	OECD	IRL
Annex Figure 5.1. STEM Employment and Labor Force Participation	ACS	USA
Annex Figure 5.2. Female Sectoral Employment Distribution	ACS	USA

Note: Country names use International Organization for Standardization (ISO) country codes. ACS = American Community Survey (United States); AEs = advanced economics; EMs = emerging markets; EMDEs = emerging market and developing economies; GEIH = Gran Encuesta Integrada de Hogares (Colombia); ILO = International Labour Organization; LICs = low-income countries; LFS = Labor Force Survey (United Kingdom); LMD = Labor Market Dynamics in South Africa Survey (South Africa); OECD = Organisation for Economic Co-operation and Development; PNADC = Pesquisa Nacional por Amostra de Domicilios Continua (Brazil); UNDP = UN Development Programme.

Country Coverage

ISO3	Country Name	Income Group	ISO3	Country Name	Income Group
AFG	Afghanistan	LIC	JOR	Jordan	EM
AGO	Angola	EM	KHM	Cambodia	LIC
ALB	Albania	EM	KIR	Kiribati	LIC
ARE	United Arab Emirates	EM	KOS	Kosovo	EM
AUT	Austria	AE	LKA	Sri Lanka	EM
BDI	Burundi	LIC	LTU	Lithuania	AE
BEL	Belgium	AE	LUX	Luxembourg	AE
BGD	Bangladesh	LIC	LVA	Latvia	AE
BIH	Bosnia and Herzegovina	EM	MDV	Maldives	EM
BLR	Belarus	EM	MEX	Mexico	EM
BLZ	Belize	EM	MHL	Marshall Islands	EM
BOL	Bolivia	EM	MKD	North Macedonia	EM
BRA	Brazil	EM	MMR	Myanmar	LIC
BRB	Barbados	EM	MNG	Mongolia	EM
BRN	Brunei Darussalam	EM	MUS	Mauritius	EM
BTN	Bhutan	LIC	NGA	Nigeria	LIC
BWA	Botswana	EM	NLD	Netherlands	AE
CHE	Switzerland	AE	NOR	Norway	AE
CHL	Chile	EM	NRU	Nauru	EM
CIV	Côte d'Ivoire	LIC	PAK	Pakistan	EM
COD	Congo, Democratic Republic of the	LIC	PAN	Panama	EM
COL	Colombia	EM	PHL	Philippines	EM
CRI	Costa Rica	EM	PLW	Palau	EM
CYP	Cyprus	AE	PNG	Papua New Guinea	LIC
CZE	Czechia	AE	POL	Poland	EM
DEU	Germany	AE	PRT	Portugal	AE
DNK	Denmark	AE	ROU	Romania	EM
DOM	Dominican Republic	EM	RWA	Rwanda	LIC
ECU	Ecuador	EM	SEN	Senegal	LIC
EGY	Egypt	EM	SLB	Solomon Islands	LIC
ESP	Spain	AE	SLE	Sierra Leone	LIC
EST	Estonia	AE	SLV	El Salvador	EM
FIN	Finland	AE	SRB	Serbia	EM
FRA	France	AE	SUR	Suriname	EM
FSM	Micronesia, Federated States of	EM	SVK	Slovakia	AE
GBR	United Kingdom	AE	SWE	Sweden	AE
GIN	Guinea	LIC	SWZ	Eswatini	EM
GMB	Gambia	LIC	SYC	Seychelles	EM
GNB	Guinea-Bissau	LIC	THA	Thailand	EM
GRC	Greece	AE	TLS	Timor-Leste	LIC
GRD	Grenada	EM	TON	Tonga	EM
GUY	Guyana	EM	TUN	Tunisia	EM
HND	Honduras	LIC	TUV	Tuvalu	EM
HRV	Croatia	AE	UGA	Uganda	LIC
HUN	Hungary	EM	URY	Uruguay	EM
IND	India	EM	USA	United States	AE
IRL	Ireland	AE	VNM	Vietnam	LIC
IRQ	Iraq	EM	VUT	Vanuatu	EM
ISL	Iceland	AE	ZAF	South Africa	EM
ITA	Italy	AE	ZMB	Zambia	LIC

Source: World Economic Outlook
Note: AE = advanced economy; EM = emerging market; LIC = low-income country.

Annex Table 1.2. Country Sample Coverage

Annex 2. Labor Market Returns Regression Analysis

Regression Specification

We formalize our previous descriptive statistics results by studying the green jobs, women, and their interaction in a regression analysis. Specifically, we perform a Mincerian regression in the spirit of Bluedorn and others (2023) described by

$$\ln\left(w_{c,i,t}\right) = \alpha_c + \beta_c^f \mathbb{1}[\text{female}_{c,i,t} = 1] + \beta_c^g \mathbb{1}\left[\text{green}_{c,i,t} = 1\right] + \beta_c^{fg} \mathbb{1}[\text{female}_{c,i,t} = 1]\mathbb{1}\left[\text{green}_{c,i,t} = 1\right] + \gamma_c X_{c,i,t} + \varepsilon_{i,t},$$

where $w_{c,i,t}$ is the wage-per-hour remuneration, $\mathbb{1}\left[\text{female}_{c,i,t} = 1\right]$ is a woman indicator, $\mathbb{1}\left[\text{green}_{c,i,t} = 1\right]$ is a green job indicator, and $X_{c,i,t}$ is a control vector that encompasses age cohorts, education, experience, marriage status, sectors, and informality (for emerging markets). We report in this regression the percentage change in wage-per-hour remuneration from being a woman, from working in a green job, and from the cross-effect of being a woman working in a green job. Annex Table 2.1 shows the coefficient results of the regression. We find there is a statistically significant positive interaction between green jobs and women across countries. In other words, we find evidence that green jobs disproportionately increase the wages of women, suggesting a smaller gender pay gap after controlling for several other important variables.[24]

Annex Table 2.1. Mincerian Regression Analysis over Gender and Job's Greenness

	Brazil	Colombia	South Africa	United Kingdom	United States
Female	–0.22***	–0.14***	–0.09***	–0.11***	–0.15***
(β_c^f)	(0.004)	(0.006)	(0.013)	(0.007)	(0.001)
Green	0.04***	0.09***	0.24***	0.04***	0.11***
(β_c^g)	(0.003)	(0.006)	(0.018)	(0.010)	(0.001)
Female×Green	0.02**	0.07***	0.20***	0.07***	0.05***
(β_c^{fg})	(0.008)	(0.011)	(0.046)	(0.018)	(0.002)
Age	Yes	Yes	Yes	Yes	Yes
Education	Yes	Yes	Yes	Yes	Yes
Married	Yes	Yes	Yes	Yes	Yes
Married-Female	Yes	Yes	Yes	Yes	Yes
Sector	Yes	Yes	Yes	Yes	Yes
Informality	Yes	Yes	Yes	No	No
Observations	565,452	119,801	55,437	30,028	5,563,305
R-squared	0.393	0.539	0.189	0.391	0.290

[24] Results pertaining to polluting jobs, as depicted in Figure 8, are available upon request from the authors.

Sources: American Community Survey (United States, 2019); Gran Encuesta Integrada de Hogares (Colombia, 2022); Labor Force Survey (United Kingdom, 2022); Labor Market Dynamics in South Africa Survey (South Africa, 2019); and Pesquisa Nacional por Amostra de Domicilios Continua (Brazil, 2022).

Note: Statistical significance of coefficients is described by * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$. Numbers in parentheses depict the standard deviation of coefficients. Sample is restricted to employed individuals. Age controls are cohorts of five years from 15 to 64 years old. Education controls are less than elementary finished, elementary finished, high school finished, and college finished or more. Sector controls are main International Standard Industrial Classification aggregates. Green is measured by having a green job index at least of 5 percent.

Annex 3. Local Projection Model

Regression Specification

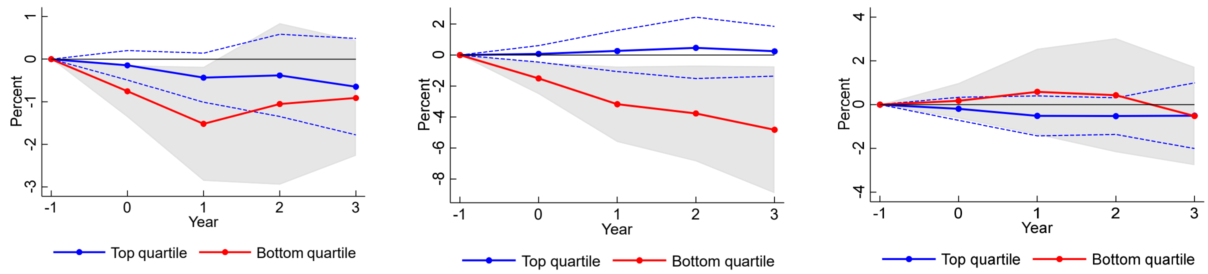
We employ the local projection method proposed by Jordà (2005) to estimate the effects of energy taxes on GHG emissions conditional on a country's level of labor market reforms covering regulations, education, and gender dimensions. Specifically, our panel local projection model conditional on labor market reforms takes the following form: $y_{i,t+h} - y_{i,t-1} = \alpha_i + \gamma_t + \beta_h^1 \epsilon_{i,t}^{tax} + \beta_h^2 (\epsilon_{i,t}^{\text{tax}} \times \text{LM}_{\text{i,t}}) + \theta X_{i,t} + \varepsilon_{i,t+h}, h = 0,\ 1,\ 2,\ and\ 3$, where $y_{i,t}$ is the log of GHG emissions intensity of GDP, α_i and γ_t denote country and year fixed effects, which control for unobservable cross-country heterogeneities and common global factors such as global business cycle, respectively. LM considers labor market conditions and is a categorical variable where countries are put into three bins in each year: bottom 25 percentile (that is, bottom reformers), top 25 percentile (that is, top reformers) and middle (between the 25 and 75 percentiles) of the distribution of reform levels. β_h^2 is our coefficient of interest and captures whether top reformers and bottom reformers would react differently following a shock to energy taxes, $\epsilon_{i,t}^{tax}$. $X_{i,t}$ is a vector of control variables, including two lags of the dependent variable, energy tax shock, economic growth, other reform shocks, and log of GDP per capita (proxy for country income level). Importantly, we also control for the two interactions—$\epsilon_{i,t}^{\text{tax}} \times \text{FG}_{\text{i,t}}$ and $\epsilon_{i,t}^{\text{tax}} \times \text{TE}_{\text{i,t}}$, where FG considers the first generation reforms (governance, business regulation, and external sector reforms; see Budina and others 2023) and TE considers the share of workers with at least tertiary education. Both FG and TE are categorical variables constructed similar to LM, and their inclusion could help us check whether the labor market conditions still play an independent role in the transmission of energy tax shocks into GHG emissions. The estimation is done via ordinary least squares, and Driscoll and Kraay (1998) robust standard errors are applied.

Energy tax, as used in this note, has three components: (1) taxes on energy products for transport purposes (for example, petrol, diesel, natural gas, and kerosene), (2) taxes on energy products for stationary purposes (for example, biofuels, fuel oil, and district heat and electricity consumption and production), and (3) GHG emissions taxes. To remove output fluctuation effects from the energy-tax-revenue-to-GDP ratio, we follow two steps. First, we estimate the following equation: $y_{i,t} = \alpha_i + \beta_k X_{i,t} + \varepsilon_{i,t}$, where $y_{i,t}$ is the energy-tax-revenue-to-GDP ratio and $X_{i,t}$ is a vector of independent variables including current and past growth (up to two lags). Second, we take the residual, $\varepsilon_{i,t}$, which represents the non-growth-related component of the ratio, to serve as a proxy for the energy tax shock. The data set is obtained from the IMF's Climate Change Indicators Dashboard.

Although using the shock identified from cyclically adjusted tax revenue for the empirical analysis helps broaden the country-year coverage, there are limitations to this shock identification method, such as endogeneity and fiscal foresight issues. To mitigate these concerns to some extent, we control for interactions between the shock and two key policy indicators (that is, first-generation reform and share of workers with at least tertiary education) in addition to standard controls. To address fiscal foresight, we include public perception about climate change in a robustness check, as firms and individuals who are more climate-aware may anticipate policy changes related to climate and adjust their behavior accordingly. This approach is used because rich cross-country data on the announcement dates and potential revenue effects for each energy-related tax policy change is not readily available. In other robustness checks, we use GHG emissions instead of GHG emissions per GDP or replace the energy tax revenue with pollution tax revenue to identify tax shocks. The results on GHG mitigation still hold. Although the use of carbon tax rates could be less subject to endogeneity than revenue-based measures (Riera-Crichton, Vegh, and Vuletin 2016), the country-year coverage of carbon tax rates is very limited for the analysis this note focuses on.

Annex Figure 3.1. Impact of Energy Taxes on GDP Conditional on Labor Market Reforms

1. Conditional on STEM Graduates
2. Conditional on Gender Equality
3. Conditional on Women, Business, and the Law



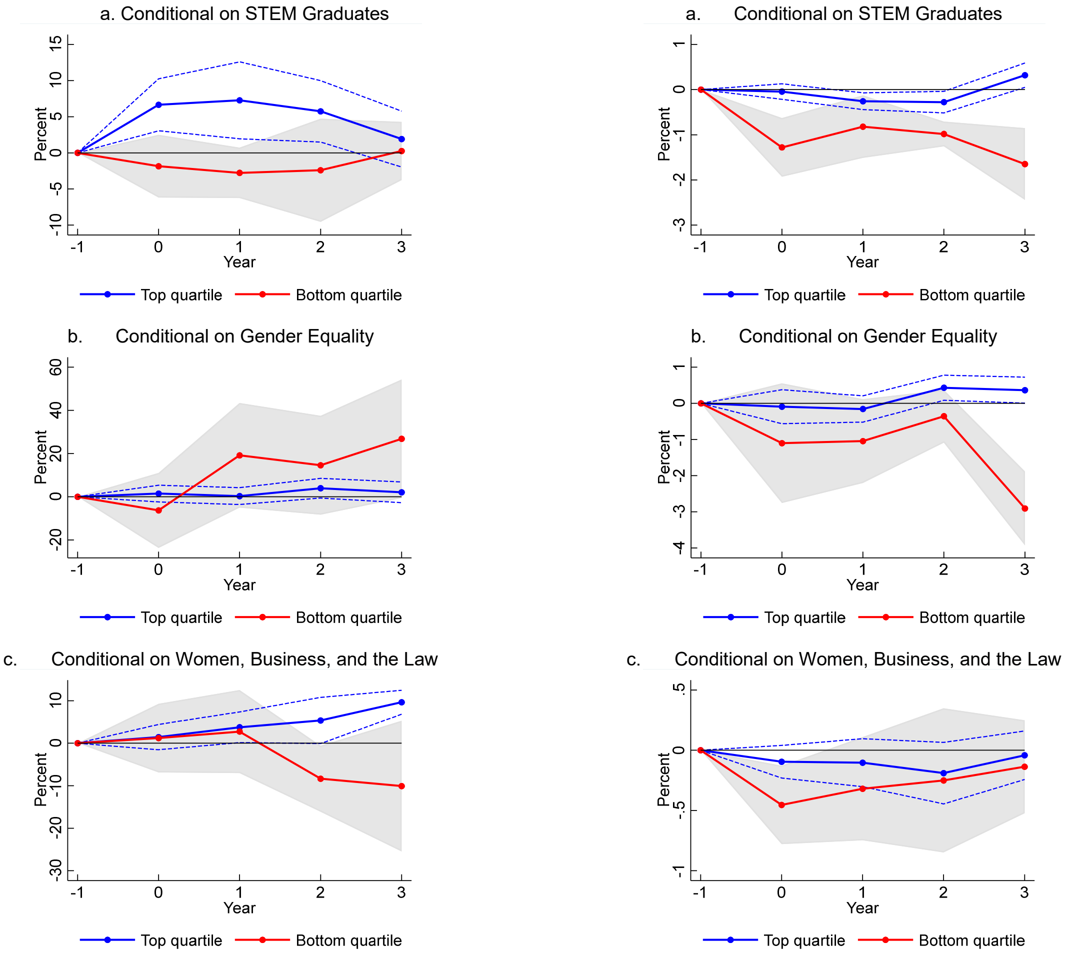
Sources: Fraser Institute; IMF, Climate Change Indicators Dashboard; UN Development Programme; World Bank; and IMF staff calculations.
Note: *t* = 0 is the year of the shock. The lines denote the response to a major historical change in the energy-tax-revenues-to-GDP ratio (one standard deviation, or 1 percentage point of GDP). The dashed lines and shaded bands indicate the 90 percent confidence interval. The analysis is based on a sample of 35 AEs and 73 EMDEs from 2003 to 2020. The figure shows the impact of energy tax conditional on gaps in labor market reforms. The index of “women, business, and the law” analyzes not only the pace of legal reforms to create equal economic opportunities for women, but also countries’ efforts to implement those laws. The other two labor market condition indicators show the share of graduates from STEM and gender equality in three dimensions including (1) reproductive health, (2) empowerment, and (3) the labor market. The energy tax shock is measured as the change in the residual term from an equation that regresses the energy-tax-revenue-to-GDP ratio on current and past growth (one and two lags). AEs = advanced economies; EMDEs = emerging market and developing economies; STEM = science, technology, engineering, and mathematics.

This local projection model also helps study the output effects of an energy tax, potentially indicating which labor market reforms could mitigate the economic growth burden of the energy tax hike. Annex Figure 3.1 shows that policies promoting pro-market regulations (that is, more flexible wage determination), gender equality, and the STEM share of graduates could reduce more GHG emissions, at the lower expense of output, when energy tax are hiked.

Annex Figure 3.2. Possible Transmission Channels for the Impact of Energy Tax on GHG Mitigation

1. Green Innovation: Cumulative Percentage Change in the Number of Green Patent Filings

2. Green Employment: Cumulative Percentage Point Change in the Share of Green Jobs

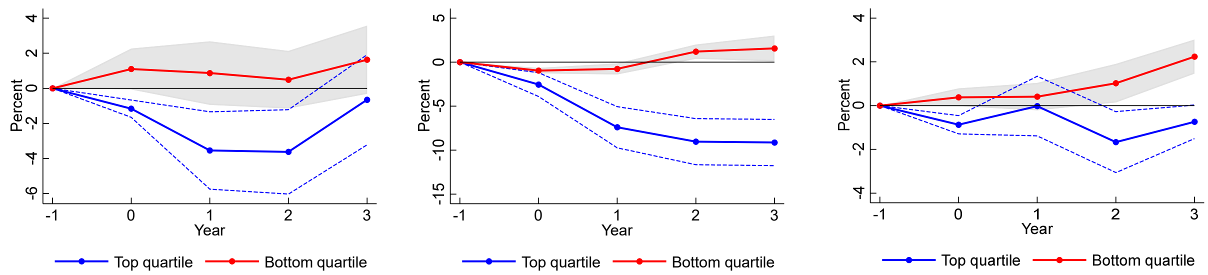


Sources: Fraser Institute; Hasna and others (2023); ILO calculations based on data from the ILO Harmonized Microdata Repository; IMF, Climate Change Indicators Dashboard; UN Development Programme; World Bank; and IMF staff calculations.
Note: *t* = 0 is the year of the shock. The lines denote the response to a major historical change in the energy-tax-revenues-to-GDP ratio (one standard deviation, or 1 percentage point of GDP). The dashed lines and shaded bands indicate the 90 percent confidence interval. The analysis is based on a sample of 35 AEs and 73 EMDEs from 2003 to 2020. The figure shows the impact of energy tax conditional on gaps in labor market reforms. The energy tax shock is measured as the change in the residual term from an equation that regresses the energy-tax-revenue-to-GDP ratio on current and past growth (one and two lags). See Annex 3 for methodological details and indicator definition. Green innovation is measured as the number of green patent filings, and green employment is the share of green jobs. One caveat when interpreting the results on green employment is that the green job data coverage in EMDEs is limited. The test for the difference in response between top and bottom reformers is also provided in Annex Figure 3.4. AEs = advanced economies; EMDEs = emerging market and developing economies; GHG = greenhouse gas; ILO = International Labour Organization; STEM = science, technology, engineering, and mathematics.

Annex Figure 3.2 shows the additional results on the transmission channels. It should be noted that other channels might also exist. However, due to the availability of data and the specific focus of this note, we only study these two channels. Annex Figure 3.3 shows the response of GHG emissions intensity to change in climate policy count and Annex Figure 3.4 reassures the difference in response of energy tax shock between top and bottom reformers is statistically significant.

Annex Figure 3.3. Impact of Climate Policy Count on GHG Emissions Intensity Conditional on Labor Market Reforms

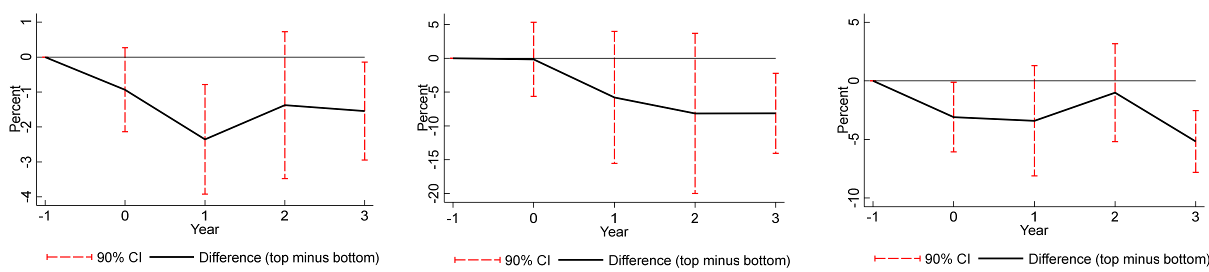
1. Conditional on STEM Graduates
2. Conditional on Gender Equality
3. Conditional on Women, Business, and the Law



Sources: Fraser Institute; IMF, Climate Change Indicators Dashboard; UN Development Programme; World Bank; and IMF staff calculations.
Note: *t* = 0 is the year of the shock. The lines denote the response to a 10 percentage point increase in the growth rate of climate policy count. The dashed lines and shaded bands indicate the 90 percent confidence interval. The analysis is based on a sample of 35 AEs and 73 EMDEs from 2003 to 2020. The figure shows the impact of energy tax conditional on gaps in labor market reforms. The index of "women, business, and the law" analyzes not only the pace of legal reforms to create equal economic opportunities for women, but also countries' efforts to implement those laws. The other two labor market condition indicators show the share of graduates from STEM and gender equality in three dimensions including (1) reproductive health, (2) empowerment, and (3) the labor market. AEs = advanced economies; EMDEs = emerging market and developing economies; GHG = greenhouse gas; STEM = science, technology, engineering, and mathematics.

Annex Figure 3.4. Difference in Response of GHG Emissions Intensity between Top and Bottom Reformers

1. Conditional on STEM Graduates
2. Conditional on Gender Equality
3. Conditional on Women, Business, and the Law



Sources: Fraser Institute; IMF, Climate Change Indicators Dashboard; UN Development Programme; World Bank; and IMF staff calculations.
Note: *t* = 0 is the year of the shock. Dashed whiskers denote the 90 percent CIs. CI = confidence interval; STEM = science, technology, engineering, and mathematics.

Overview of Labor Market Reform Indicators

Gender Equality Index

This index is a composite measure reflecting equality in achievement between women and men in three dimensions: (1) reproductive health, (2) empowerment, (3) and labor market. It ranges from 0, where one gender fares as poorly as possible in all measured dimensions, to 1, where women and men fare equally.

Women, Business, and the Law Index

The index measures how laws and regulations affect women's economic opportunity. Overall scores are calculated by taking the average score of each subindex (mobility, workplace, pay, marriage, parenthood, entrepreneurship, assets and pension), with 100 representing the highest possible score.

Graduates in STEM

It measures the share (in percentage) of all tertiary graduates who completed STEM programs.

Annex 4. Model

Final Good Producer

The final good representative producer uses green (M_G), brown (M_B), and neutral (M_N) intermediate inputs and is a profit-maximization agent taking as given the market prices and tax rates to brown intermediate inputs. First, the brown and green intermediate inputs are aggregated using a constant elasticity of substitution (CES) function. Afterwards, the neutral intermediate inputs with the previous aggregation are compounded using a Cobb-Douglas function. The technologies described are expressed by

$$F(M_N, M_G, M_B) = M_N^{\alpha}\left[\left(\omega M_G^{-\eta} + (1-\omega)M_B^{-\eta}\right)^{-1/\eta}\right]^{1-\alpha},$$

where $\omega \in (0,1)$ represents the weight of green intermediate inputs, $\eta \geq -1$ represents the elasticity of substitution between green and brown intermediate inputs, and $\alpha \in (0,1)$ represents the weight of neutral intermediate inputs.

Neutral Intermediate Producer

The neutral intermediate representative producer uses male and female high-skilled workers ($L_N^{H,m}, L_N^{H,f}$) and male and female low-skilled workers ($L_N^{L,m}, L_N^{L,f}$) labor inputs, and is a profit-maximization agent using the market prices for neutral intermediates, wages for high-skilled men and women workers, and for the low-skilled men and women workers. The high-skilled labor and low-skilled labor are aggregated using a CES function. Afterwards, the high-skilled and low-skilled labor composites are aggregated using a Cobb-Douglas function. The technologies described are expressed by

$$F_N\left(L_N^{H,m}, L_N^{H,f}, L_N^{L,m}, L_N^{L,f}\right) = z_N\left[\left(\left(L_N^{H,m}\right)^{-\eta_H} + \theta_N^H\left(L_N^{H,f}\right)^{-\eta_H}\right)^{-1/\eta_H}\right]^{\alpha_N}\left[\left(\left(L_N^{L,m}\right)^{-\eta_L} + \theta_N^L\left(L_N^{L,f}\right)^{-\eta_L}\right)^{-1/\eta_L}\right]^{1-\alpha_N},$$

where $\theta_N^H, \theta_N^L \in (0,1)$ respectively represents the productivity contractor of high-skilled and low-skilled women labor in neutral jobs, $\eta_H, \eta_L \geq -1$ respectively represents the elasticity of substitution between high-skilled and low-skilled labor between men and women, $\alpha_N \in (0,1)$ represents the weight of high-skilled labor in the neutral sector, and z_N represents the technology in the neutral sector.

Green Intermediate Producer

The green intermediate representative producer uses male and female high-skilled workers ($L_G^{H,m}, L_G^{H,f}$) and male and female low-skilled workers ($L_G^{L,m}, L_G^{L,f}$) labor inputs, and is a profit-maximization agent using the market prices for green intermediates, wages for high-skilled men and women workers, and for the low-skilled men and women workers. The high-skilled labor and low-skilled labor are aggregated using a CES function. Afterwards, the high-skilled and low-skilled labor composites are aggregated using a Cobb-Douglas function. The technologies described are expressed by

$$F_G\left(L_G^{H,m}, L_G^{H,f}, L_G^{L,m}, L_G^{L,f}\right) = z_G\left[\left(\left(L_G^{H,m}\right)^{-\eta_H} + \theta_G^H\left(L_G^{H,f}\right)^{-\eta_H}\right)^{-1/\eta_H}\right]^{\alpha_G}\left[\left(\left(L_G^{L,m}\right)^{-\eta_L} + \theta_G^L\left(L_G^{L,f}\right)^{-\eta_L}\right)^{-1/\eta_L}\right]^{1-\alpha_G},$$

where $\theta_G^H, \theta_G^L \in (0,1)$ respectively represents the productivity contractor of high-skilled and low-skilled women labor in green jobs, $\eta_H, \eta_L \geq -1$ respectively represents the elasticity of substitution between high-skilled and low-skilled labor between men and women, $\alpha_G \in (0,1)$ represents the weight of high-skilled labor in the green sector, and z_G represents the technology in the green sector.

Polluting Intermediate Producer

The polluting intermediate representative producer uses male and female high-skilled workers ($L_B^{H,m}, L_B^{H,f}$) and male and female low-skilled workers ($L_B^{L,m}, L_B^{L,f}$) labor inputs, and is a profit-maximization agent using the market prices for brown intermediates, wages for high-skilled men and women workers, and for the low-skilled men and women workers. The high-skilled labor and low-skilled labor are aggregated using a CES function. Afterwards, the high-skilled and low-skilled labor composites are aggregated using a Cobb-Douglas function. The technologies described are expressed by

$$F_B\left(L_B^{H,m}, L_B^{H,f}, L_B^{L,m}, L_B^{L,f}\right) = z_B \left[\left(\left(L_B^{H,m}\right)^{-\eta_H} + \theta_B^H \left(L_B^{H,f}\right)^{-\eta_H}\right)^{-1/\eta_H}\right]^{\alpha_B} \left[\left(\left(L_B^{L,m}\right)^{-\eta_L} + \theta_B^L \left(L_B^{L,f}\right)^{-\eta_L}\right)^{-1/\eta_L}\right]^{1-\alpha_B},$$

where $\theta_B^H, \theta_B^L \in (0,1)$ respectively represents the productivity contractor of high-skilled and low-skilled women labor in brown jobs, $\eta_H, \eta_L \geq -1$ respectively represents the elasticity of substitution between high-skilled and low-skilled labor between men and women, $\alpha_B \in (0,1)$ represents the weight of high-skilled labor in the brown sector, and z_B represents the technology in the brown sector.

Representative Households

The representative households encompass high- and low-skilled gendered workers that supply labor hours to the green, brown, and neutral sectors. Male and female representative households have a share $\psi^f, \psi^m \in (0,1)$ of high-skilled workers. The representative households derive utility solely from the consumption of final goods which they purchase by men supplying a unit of labor hours to the market and women supplying a fixed faction of a unit.

The representative worker chooses the share of labor hours in each sector considering the labor taxes (τ) and the hourly wages in the neutral ($w_N^{j,g}$), green ($w_G^{j,g}$), and brown ($w_B^{j,g}$), where the worker skill is represented by $j \in \{H, L\}$ and the gender by $g \in \{m, f\}$.The maximization problem of the representative worker can be represented by

$$\text{Max}\{\ln(c^{j,g})\} \text{ subject to } c^{j,g} = (1-\tau)\left(w_N^{j,g} l_N^{j,g} + w_G^{j,g} l_G^{j,g} + w_B^{j,g} l_B^{j,g}\right) \text{ and } \bar{L}^g = l_N^{j,g} + l_G^{j,g} + l_B^{j,g},$$

where $\tau \geq 0$ represents the labor tax rate the government levies to labor earnings and $\bar{L}^m = 1$ and $\bar{L}^f < 1$ represents the total hours labor supply for men and women.

Government Budget Constraint

The government balances its revenues and expenditures to keep a balanced budget every period. The expenditures of the government encompass an environmental costs contingent in the brown intermediate output existent in the economy. The environmental costs are increasing and concave expressed by $K(Y_B) = \kappa Y_B^{1+\zeta}$, where $\kappa, \zeta > 0$. In addition, the government finances high-skilled workers education for men and women paying a price p^H. On the revenues side, the government levies taxes on household earnings and on the intermediate purchases of brown inputs for the final good production. Joining the expenditures and the revenues, the government balanced budget conditions is expressed by

$$K(Y_B) + p^H(\psi^f\, \bar{L}^f + \psi^m\, \bar{L}^m) = \tau_B p_B M_B + \sum_{j\in\{H,L\}} \sum_{i\in\{N,G,B\}} \sum_{g\in\{f,m\}} \tau w_i^{j,g} l_i^{j,g}.$$

Market Clearing

The wages for women ensure the female labor markets clear:

$$L_G^{H,f} = \gamma_H \psi^f l_G^{H,f}, L_B^{H,f} = \gamma_H \psi^f l_B^{H,f}, L_N^{H,f} = \gamma_H \psi^f l_N^{H,f}, \text{ and}$$

$$L_G^{L,f} = \gamma_L (1-\psi^f) l_G^{L,f}, L_B^{L,f} = \gamma_L (1-\psi^f) l_B^{L,f}, L_N^{L,f} = \gamma_L (1-\psi^f) l_N^{L,f}.$$

The wages for men ensure the male labor markets clear:

$$L_G^{H,m} = \gamma_H \psi^m l_G^{H,m}, L_B^{H,m} = \gamma_H \psi^m l_B^{H,m}, L_N^{H,m} = \gamma_H \psi^m l_N^{H,m}, \text{ and}$$

$$L_G^{L,m} = \gamma_L (1-\psi^m) l_G^{L,m}, L_B^{L,m} = \gamma_L (1-\psi^m) l_B^{L,m}, L_N^{L,m} = \gamma_L (1-\psi^m) l_N^{L,m}.$$

The intermediate prices ensure the intermediate goods markets clear:

$$M_B = F_B\left(L_B^{H,m}, L_B^{H,f}, L_B^{L,m}, L_B^{L,f}\right), M_G = F_G\left(L_G^{H,m}, L_G^{H,f}, L_G^{L,m}, L_G^{L,f}\right), \text{and } M_N = F_N\left(L_N^{H,m}, L_N^{H,f}, L_N^{L,m}, L_N^{L,f}\right).$$

Lastly, the feasibility condition is satisfied:

$$\psi^f c^{H,f} + (1-\psi^f) c^{L,f} + \psi^m c^{H,m} + (1-\psi^m) c^{L,m} + K(M_B) + p^H(\psi^f \bar{L}^f + \psi^m \bar{L}^m) = F(M_N, M_G, M_B)$$

Calibration Strategy

The model has 26 parameters in total; we divide them into two blocks to set their values. The first block consists in 11 parameters and is calibrated directly from the data or taken from the literature. The second block consists in 15 parameters and is calibrated to match key moments from the US data. Annex Table 4.1 enlists the model parameters, their value and description, and the source. Annex Table 4.2 compares the moments between the data and the model. The calibration strategy aims to capture the US experience; therefore, we use the American Community Survey of 2019. The model captures the features of the data apart from the men in STEM, slightly overperforming in the green and polluting sector and underperforming in the neutral sector. Likewise, the polluting share in production slightly underperforms as well.

Annex Table 4.1. Calibration Strategy and Parameter Values

Description	Parameter	Value	Source
Exogenous calibration			
Elasticity of substitution between green and polluting energy $1/(1+\eta) = 2.8)$	η	–0.65	Papageorgiou and others (2017)
Wage return to no STEM worker on average	γ_H	2.85	Data ACS, 2019
Wage return to STEM worker on average	γ_L	1.00	Normalization
Elasticity of substitution between men and women not in STEM $1/(1+\eta_L) = 1.0)$	η_L	0.00	Ostry and others (2018)
Elasticity of substitution between men and women in STEM $(1/(1+\eta_H) = 1.0)$	η_H	0.00	Ostry and others (2018)
Share of employed STEM women	ψ^f	0.10	Data ACS, 2019
Share of employed STEM men	ψ^m	0.02	Data ACS, 2019
Male labor force participation	$\bar{L}^f$	1.00	Normalization
Female labor force participation	$\bar{L}^m$	0.77	Data value
Polluting output externality convex curvature	ζ	0.50	Semi-quadratic
Price of STEM education	p^H	1.19	College cost to GDP
Target moments calibration			

Green energy weight	ω	0.83
Share of neutral goods in production	α	0.77
Share of STEM workers in green sector	α_G	0.49
Share of STEM workers in neutral sector	α_N	0.35
Share of STEM workers in polluting sector	α_B	0.37
Green sector productivity	z_G	1.72
Neutral sector productivity	z_N	1.29
Polluting sector productivity	z_B	1.83
Female labor productivity contractor in green sector for STEM workers	θ_G^H	0.15
Female labor productivity contractor in green sector for no STEM workers	θ_G^L	0.20
Female labor productivity contractor in polluting sector for STEM workers	θ_B^H	0.03
Female labor productivity contractor in polluting sector for no STEM workers	θ_B^L	0.19
Female labor productivity contractor in neutral sector for STEM workers	θ_N^H	0.48
Female labor productivity contractor in neutral sector for no STEM workers	θ_N^L	0.94
Average labor tax rate	τ	0.22

Source: IMF staff calculations

Note: ACS = American Community Survey (United States); STEM = science, technology, engineering, and mathematics.

Annex Table 4.2. Data and Model Target Moments Calibration

Target Moment	Data	Model
Women employment share		
STEM green	0.10	0.10
STEM polluting	0.01	0.01
STEM neutral	0.89	0.89
No STEM green	0.05	0.05
No STEM polluting	0.03	0.03
No STEM neutral	0.92	0.92
Men employment share		
STEM green	0.23	0.24
STEM polluting	0.06	0.10
STEM neutral	0.71	0.66
No STEM green	0.18	0.18
No STEM polluting	0.11	0.11
No STEM neutral	0.71	0.71
Gender wage gap		
Green sector	9.6%	9.6%
Non-green sector	14.5%	14.5%
Green and polluting		
Green share in energy	20%	20%
Polluting production share	10%	7%
Green production share	5%	5%
Polluting output externality		
Average labor tax rate	0.24	0.22

Source: IMF staff calculations

Note: STEM = science, technology, engineering, and mathematics.

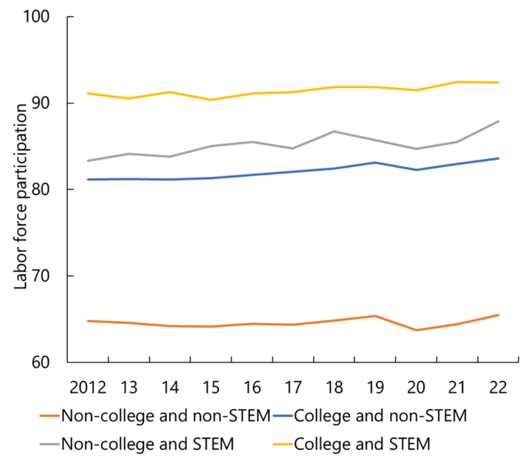
Annex 5. Women Employment in STEM

Examining the employment patterns of women in STEM fields provides insight into how educational background and sectoral distribution impact labor force participation and highlight opportunities to increase female representation in these critical areas.

In the United States, female labor force participation in STEM is impressively high. Among women with a college degree, more than 90 percent participate in the labor force, a figure that has increased by more than 1 percentage point recently (Annex Figure 5.1). The three most prominent occupations for these women are engineering professionals, civil engineers, and information and communications technology sales representatives. Conversely, female labor participation for women with a college education but without a STEM degree is close to 87 percent and has also risen by almost 3 percentage points in recent years.

Annex Figure 5.1. STEM Employment and Labor Force Participation

(Percent)



Sources: American Community Survey (United States, 2012–22); and IMF staff calculations.
Note: The figure plots the labor force participation for women in the United States over the period from 2012 to 2022, broken down by college education and employment in STEM (defined as whether the individual is currently employed in a STEM occupation or their most recent occupation was in STEM). STEM = science, technology, engineering, and mathematics.

There exists a notable gap in labor force participation among women without a college degree between those in STEM versus non-STEM occupations. Among women without a college degree engaged in STEM occupations, participation is also high, exceeding 80 percent and on an upward trend. These women are predominantly employed as information and communications technology sales representatives, medical sales professionals, and engineering technicians. In contrast, women in non-STEM occupations without a college degree have a labor participation rate closer to 65 percent.

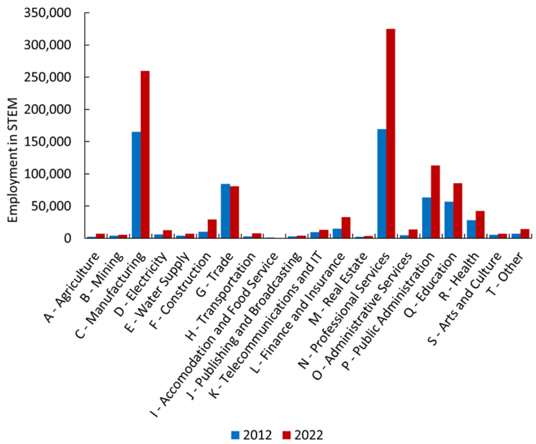
Interestingly, the sectoral distribution of STEM jobs is evolving, particularly among women with a college degree (Annex Figure 5.2). Increasingly, these women are employed in professional services, which include sectors such as research, engineering and computer systems, and less so in the trade sectors. Additionally, there has been a notable shift toward manufacturing jobs. On the other hand, for women without a college degree, the most significant increases have been observed in the health and education sectors.

Professional jobs are also more amenable to telework, and studies suggest that women have a higher preference for such jobs due to the better work-life balance they offer. In the first half of 2023, American women worked from home slightly more than men, with 29.3 percent of paid workdays compared to men's 27 percent, influenced by higher education levels among women and their preference for reduced commuting times (Barrero, Bloom, and Davis 2023). The surge in remote work and increased flexibility has also correlated strongly with a rise in female labor force participation during the pandemic. According to Jaumotte and others (2023), countries with a higher proportion of workers engaged in remote work experienced a faster rebound in female labor force participation.

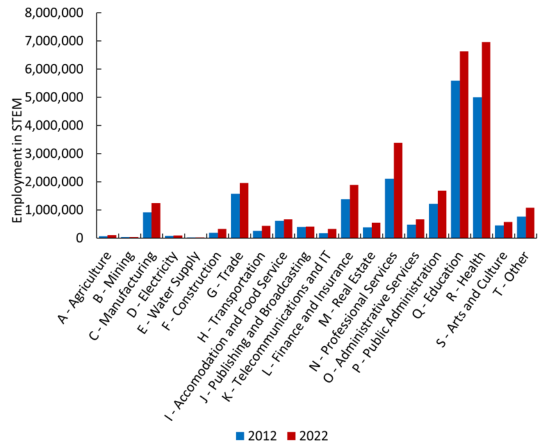
Looking ahead, as the demand for STEM qualifications grows and the world increasingly embraces remote work, the teleworkability of jobs could serve as a crucial lever to attract more women to STEM fields and sectors where flexibility is viable. This shift could not only help balance gender disparities in STEM but also enhance overall job satisfaction and participation rates among women.

Annex Figure 5.2. Female Sectoral Employment Distribution

1. College



1. Non-college



Sources: American Community Survey (United States, 2012 and 2022); and IMF staff calculations.
Note: The figure shows the total amount of women employed in STEM occupations in 2012 and 2022 by industry section. Panel 1 shows employment for those with college degrees, and panel 2 shows the employment for workers without college education. STEM = science, technology, engineering, and mathematics.

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Green Jobs and the Future of Work for Women and Men

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