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Does Gender Climate Influence Climate Change? The Multidimensionality of Gender Equality and Its Countervailing Effects on the Carbon Intensity of Well-Being

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Abstract: The carbon intensity of well-being (CIWB) (a ratio measuring the amount of CO_2 emitted per unit of life expectancy at birth) is an increasingly popular way to measure the ecological efficiency of nations. Although research demonstrates that economic development typically reduces this efficiency, little research has explored the extent to which social equality improves it. This study uses panel data for 70 nations between 1995 and 2013 to assess how various aspects of gender equality affect the ecological efficiency of nations. We estimate a series of Prais-Winsten regression models with panel-corrected standard errors (PCSE) to assess how increases in the percentage of women in parliament, expected years of education for women, and the percentage of women in the labor force independently affect CIWB. Our findings indicate that across all nations, increases in the percentage of women in parliament and expected years of schooling reduce CIWB; however, increases in the percentage of women in the labor force increase CIWB. Our results further show that the relationship between different dimensions of gender equality and CIWB differs between more developed and less developed nations. Finally, we find that increases in the number of women in parliament and women's education attenuate the relationship between women's labor force participation and CIWB. We discuss the variation in our results by reviewing relevant eco-gender literatures and feminist economics.

Keywords: gender and environment; carbon intensity of well-being; climate change; social inequality; sustainable development

1. Introduction

Climate change is arguably the greatest environmental threat humanity has ever confronted. It is global in scale, affects all other planetary systems, and is marked by increased average global temperatures, rising sea levels, and more extreme weather patterns. The changes brought about by a warming climate, including high heat and natural disasters (among others), have grave implications for both human health and the economy [1]. Increasing atmospheric concentrations of CO_2 from the combustion of fossil fuels are largely responsible for changes in our climate since the Industrial Revolution. The latest IPCC report suggests that humanity has little over a decade to halve emissions, and until mid-century to cut emissions altogether, if we are to avoid a two-degrees rise in global average temperatures [1]. A two-degree rise in average temperatures would cause parts of the earth to be uninhabitable for humans and result in agricultural losses that would exacerbate poverty and lead to food shortages. Ultimately, failing to adequately reduce emissions will likely result in a dramatic decline in well-being for most people the world over.

A commonly cited definition of sustainable development, drawn from the famous Brundtland Commission [2], suggests human well-being enhancement is best achieved via development that "meets the needs of the present without compromising the ability of future generations to meet their own needs." The United Nations (UN) Sustainable Development Goals (SDGs) outline broad targets for developing in ways that improve overall human well-being while also mitigating the risks of environmental change and reducing long-standing social inequalities. However, some powerful entities in the global development community (e.g., World Bank, International Monetary Fund) proffer economic growth as the primary means for improving quality of life and human well-being. Research demonstrates that economic growth is correlated with rising CO_2 emissions, and gains in the economy are generally unevenly distributed, such that some people benefit from growth while many others do not [3]. Marilyn Waring's research on gender inequality and economic development reported the deleterious effects of women's nationally invisible, unpaid labor on their rights and autonomy [4,5]. As research has since clearly articulated distinct disparities in the social and economic conditions of nations and their populations, the UN began reporting on different measures of human well-being that account for inequalities—in addition to simply estimating GDP per capita. It was Waring's work, for instance, that inspired the creation and maintenance of the UN's Gender Inequality Index (GII). This study interrogates how we may improve quality of life while also mitigating climate change. If we can improve human well-being without increasing emissions, then we may more persuasively argue for systemic changes in the type and quality of future development programs.

Inequalities in income, race, and gender, greatly affect well-being and have economic and environmental implications that cannot be understood in isolation from one another. A rich body of empirical work demonstrates links between social inequalities and environmental problems. Specifically, increased income inequality is associated with greater biodiversity loss, resource consumption, waste generation, toxic emissions, and water pollution as well as lower survival rates of children under the age of five [6]. Conversely, efforts to introduce sustainability measures are enhanced by women's participation in community decision-making bodies, which lead to better protection of common property resources for everyone [7]. This research suggests that eradicating myriad social inequalities plays a critical role in advancing and realizing sustainability goals. Understanding the relationship between environmental outcomes and different dimensions of inequity allows us to consider forms of human development that simultaneously serve people and the environment.

Thus, we examine how three of the UN SDGs are interrelated, specifically, improving human well-being (goal 3), mitigating climate change (goal 13), and reducing gender inequality (goal 5). To this end, we analyze the effects of three measures of gender equality on CIWB—the ratio of anthropogenic CO_2 emissions to life expectancy at birth. We focus on CIWB because it allows us to explore whether or not reducing gender inequality influences climate change mitigation and well-being improvement simultaneously. Put differently, we evaluate if a more expeditious elimination of gender inequality has the additional benefit of facilitating improvements in well-being relative to the intensity with which societies emit CO_2.

In what follows, we explore the concept of gender equality as a force of environmental change. Prior research has focused either on a single measure of gender equality [8] or treated it as a multidimensional construct with a singular socio-ecological impact [9]. In this study, we take an alternative but complementary perspective. Indeed, while focusing on a single measure or singular effect helps to illuminate a particular environmental dynamic of gender equality, it is analytically more comprehensive to examine the different dimensions of gender equality as separate measures with independent environmental consequences. Drawing from different theoretical frameworks, we derive hypotheses suggesting that the different dimensions of gender equality will have countervailing environmental impacts.

To test these hypotheses we incorporate cross-national social and environmental data into longitudinal regression models. While structural equation modeling can help assess the statistical effect of a latent construct of gender equality [9], we utilize conventional panel modeling to estimate the independent environmental associations of individual components of the concept of gender equality. In doing so, we ask whether gender equality is a multidimensional concept with countervailing impacts on the environment. In the following sections, we provide an overview of literatures on CIWB and gender and the environment. Then, we outline our methods, data, and results.

1.1. Carbon Intensity of Well-Being (CIWB)

As a result of human economic activities, CO_2 concentrations in the atmosphere have increased by over forty percent since the Industrial Revolution [10]. Carbon dioxide is a powerful greenhouse gas that contributes to climate change. Decoupling socioeconomic development and CO_2 emissions is necessary if nations want to mitigate the effects of climate change. Calculating the CIWB yields an operational measure to quantitatively assess whether carbon emissions and human well-being are being decoupled. CIWB is a ratio measuring the amount of CO_2 emitted divided by life expectancy at birth. Thus, a change in CIWB as a result of social structural dynamics can be best understood as a change in the relationship between a society's rate of pollution, or the pace of emissions, and that society's overall well-being (operationalized here as life expectancy at birth).

Research on CIWB has developed out of macro-level quantitative analyses assessing the relationship between various forms of socioeconomic development, or well-being, and CO_2 emissions. Originally conceived of by Dietz, Rosa, and York [11,12], much of the existing research on CIWB has since been produced by Jorgenson and colleagues [3,13–16]. This research has found that modern trends in socioeconomic development within and across nations increase the CIWB over time—specifically, economic growth, increased GDP per capita, income inequality, and urbanization. The existence of slums within nations also appears to affect the relationship between urban development and the CIWB [17]. Notably, the pace at which CIWB grows seems to hinge on the qualitative character of the development process in question. While economic development is widely regarded as a means of improving human well-being, inequalities related to gender or race, among others, unevenly affect quality of life. Yet, few CIWB analyses have assessed the relationships between social inequities, other than economic, and CO_2 emissions. A notable exception is the Jorgenson et al. [15] state-level analysis of the US, which finds that both poverty and affluence for males and females increase CIWB. Specifically, they note that income inequality, or "the concentration of income among the most affluent and the percent of the population below the poverty line both increase US states' carbon intensity of well-being" [15] (p. 1172). In light of this lacunae, our study is concerned with gender equality as a component of well-being.

There are compelling reasons to include gender in CIWB analyses. Social scientists have long theorized that anthropogenic environmental change is tied to the relationship between economic development and social inequality [18]. Findings from research on gender and the environment offer insights into the significance of gender inequality, in particular, on environmental outcomes. This research demonstrates that nations where women have a larger share of parliamentary seats are more likely to ratify international environmental treaties and tend to have lower CO_2 emissions per capita [8,19]. Additionally, increases in women's educational attainment, access to health care, and paid labor force participation lead to declines in fertility rates. Population growth, in conjunction with affluence and technology, is a factor associated with environmental degradation [20–22]. In acknowledgement of such research, the international community has prioritized gender equality as a sustainable development goal (SDG 5) [23,24].

As with CO_2 emissions, a good deal of research suggests that socio-structural factors such as national level gender equality profoundly affect a nation's life expectancy at birth. Structural factors found to affect life expectancy include gender, race, income, and

educational attainment, among others [25,26]. Here, we focus on structural components of gender equality. For instance, women tend to live longer than men on average, but other intervening factors (e.g., race and class) may serve to affect life expectancy, too. Further, while racial disparities exist, those with less than a high school degree are likely to die younger than those with a high school diploma in the U.S., independent of gender and race [25,26]. Income also affects life expectancy at birth, as mortality rates for individuals in the lowest income brackets are two- to four-times higher than mortality rates for the highest income earners in the U.S. [27]. Aspects of gender inequality also adversely affect women's quality of life, life expectancy at birth, and overall well-being. Indeed, women are more likely to live in poverty, experience chronic hunger, and attain lesser education than men the world over, all of which can decrease their life expectancy and the mortality related outcomes of the society more generally [28,29]. Considering the myriad ties between the varied components of gender equality, CO_2 emissions, and life expectancy at birth, we argue that our understandings of the social mechanisms that underlie the development of socio-ecological efficiency will be substantially deepened by incorporating measures of gender inequality into analyses of CIWB. In the following sections we explore the impact of gender inequality across several dimensions, but first we delve into the theory undergirding the findings discussed above.

1.2. Theoretical Traditions on Gender and the Environment

Gender and the environment theorists disentangle connections between gender inequality and environmental harm as well as gendered differences in expressions of environmental concerns and behaviors. These scholars generally argue that, rather than essential gender characteristics, material and cultural conditions pattern gendered divisions of labor that affect how men and women interact with and experience local environments. Ecofeminists assert that capitalism is a gendered and racialized system with a core logic of domination, whereby women's reproductive labor, the labor of people of color, Indigenous peoples' lands, and ecosystems are treated as divinely ordained, free raw materials. Capitalism treats women's biological and social reproductive labor—biological reproduction, unpaid care work, and domestic labor—as natural resources, which serve to discursively and politically legitimate the exploitation of women [30,31]. Women's free reproductive labor subsidizes capital, as it ensures a constant supply of workers who also are groomed, rested, and fed [32,33]. Moreover, poor women, especially from less developed countries (LDCs), supply a steady and cheap surplus army of labor who further drive down wages [32].

Similarly, feminist political ecologists contend that material and cultural factors—such as gendered divisions of labor, knowledge, legal rights, public space access, and land and natural resource access—coalesce to affect women's behaviors and concerns for the local environment [34]. Cultural norms in most countries position women as caregivers of children, the elderly, and the ill. Thus, many women procreate future workers, nourish them, and, when they fall ill, nurse them back to health. Poor women's cultural and political subordination compounded by their lack of wealth and social capital makes them particularly vulnerable to environmental risks, especially due to natural disasters. Their caretaker responsibilities in particular can affect their vulnerability, as in the case of the 1991 cyclone in Bangladesh where some women had to evacuate small children from floods [35], and affect their concerns and actions, such as desiring and fighting for nontoxic environments for their families [36]. Different cultural and structural circumstances in Global North and South nations also contribute to varied environmental risks and vulnerabilities—which differ further by gender, race, class, caste, and religion, among other factors [34]. Among the most researched and cited reasons for women's environmental concerns and actions (for more on gendered concern see, [37–41]), are altruism [37,42], culturally prescribed caretaking responsibilities, and health and livelihood protection [36]. Considering the extensive research on disproportionate exposures, women's contributions to environmental activism, and women's expressed concerns about the environment, cross national research

has hypothesized that if women have more education, decision-making power, and hold more parliamentary positions, then their empowerment should have implications for environmental outcomes and life expectancy. Since the purpose of this paper is not to explore the mechanisms for gendered environmental behavior or concern, but rather to parse out which components of women's empowerment prohibit or facilitate pro-environmental actions, we turn to the literature on environment-empowerment connections relevant to the GII variables used in our analysis.

1.3. Decision-Making

The UN's GII measures women's empowerment by the "proportion of parliamentary seats occupied by females and proportion of adult females and males aged 25 years and older with at least some secondary education" [43]. In this section, we focus on women's influence in decision-making. As the evidence suggests that women express more environmental concern than men, researchers have hypothesized that women would make different decisions when placed in positions of political power [8,19]. Moreover, women's participation in decision-making has positive effects on maternal and child health outcomes, as well as on female and male life expectancy, across scales (e.g., the household, community, and nation) [44].

Research demonstrates that women's empowerment generally improves health outcomes for everyone. In a review of the empowerment literature, Pratley [44] finds that women's ability to make financial decisions in the household is associated with better maternal and child health outcomes, such as nutritional status and child mortality, at the national level. Evidence from India suggests that women's political representation matters at the community level as well. Specifically, after women were given mandatory leadership roles in a third of local councils, health-related public investment increased, especially for clean water access [45,46]. Indeed, the implementation of women's suffrage—in each U.S. state—was correlated with increased public health spending and legislative changes that decreased child mortality due to infectious diseases [46]. Women's increased political representation in the U.S., moreover, is associated with both men and women's increased life expectancy [46,47]. Williamson and Boehmer find that LDCs where women have had the right to vote for longer tend to have higher female life expectancy [48]. However, they find the relationship between women's representation in parliament and life expectancy is positive but not significant in LDCs cross-nationally [48]. There exists a clear connection between women's empowerment, health, and environmental outcomes, as legislation that allows for access to uncontaminated resources, such as air and water, has both human health and environmental implications.

A number of empirical analyses have explored the connection between women's political empowerment and environmental outcomes. For example, Norgaard and York [19] research environmental treaty ratification and percent of women holding seats in parliament cross-nationally. They find that nations with higher proportions of women in parliament ratify a greater number of environmental treaties. Similarly, the UN reported that, between the years 1990 and 2004, 18 of the 70 most developed nations in the world had stabilized or reduced their carbon emissions [49]. Of these 18 nations, 14 had a greater than average percentage of women as elected representatives [50]. Shandra et al. found that nations with a higher proportion of women's nongovernmental organizations (NGOs) also had lower per capita rates of deforestation [51]. Moreover, results from cross-national research conducted by Ergas and York [8] demonstrate that CO_2 emissions per capita are lower in nations where women have higher political status. McKinney's work reveals the dialectical relationship between gender inequity and environmental harm as well as improved gender equality and environmental conditions. She finds that resource degradation disproportionately effects women negatively, but women's significant representation in government "bodes well for the environment" [52]. In addition, McKinney and Fulkerson find that ecological losses weaken women's status in nations. Yet, nations with greater female representation in governing bodies have lower climate footprints [53].

Despite the above findings, Ergas and York [8] (p. 974) caution, "macro-level, cross-national data and analysis cannot readily address" the question, "why does women's representation in decision-making bodies affect environmental outcomes?" They argue instead for a more nuanced understanding of the relationship between gender and the environment that could be related to a number of phenomena, such as overall progressiveness of a nation or the generalized effects of equality on people's values:

> Since the exploitation of the environment and of women may be connected due to a common "logic of domination" which is often associated with valuing nature and people in narrow utilitarian terms, improving gender equality may serve to transform how the environment is viewed... since women are often disproportionately harmed by environmental degradation, increasing consideration for women's well-being may lead to greater awareness about environmental problems... since women generally have different knowledge about... the environment, it is entirely possible that women make different decisions than do men when placed in positions of power... [8] (974).

It makes sense that women's concern for the environment is complicated; women are not a monolithic group, and their interests vary greatly by nation, race, class, and other factors. Similarly, women's empowerment may have a more complex relationship with the environment, as different indicators of women's empowerment may have different environmental impacts. We turn to education below.

1.4. Education

The second part of the GII empowerment variable is education, measured by the "proportion of adult females and males aged 25 years and older with at least some secondary education" [43] Education is important for girls and women because more education for women is associated with longer life expectancy, for them and their children, and higher wage attainment. In addition, educated women are less likely to live in poverty and experience domestic violence, both of which can affect life expectancy. However, women and girls make up two-thirds of the world's illiterate population, and a mere 39 percent of rural girls, compared to 45 percent of rural boys, attend secondary school [28]. Research also demonstrates that there exist significant national costs to gender inequality in education. While research on links between girls' education and climate change impacts is limited, there is a growing interest in these connections [54]. In this section we explore connections between educational attainment, health outcomes, and the environment.

Most literature on women's education and environmental impacts narrowly focuses on the effect of education on fertility rates. Women have fewer children when they are more highly educated, and more highly educated populations experience decelerated population growth [55]. It follows that educating girls generally, and about family planning in particular, combined with making reproductive healthcare more accessible gives young women more options and reduces fertility [55,56]. Reducing population growth indirectly reduces demand for environmental resources and generally improves living conditions [11,57]. However, some argue that focusing on the reproduction aspects of educational attainment is limited and threatens to reinstate problematic population control measures in a seemingly more enlightened veneer [58]. Rather than narrowly focusing on population growth, researchers identify the climate mitigation and adaptation potential of educated women who are able to make informed decisions about how to prepare for and adapt to climate-related disasters.

Kwauk and Braga argue that:

> Girls' education may be one of the most overlooked yet formidable mechanisms for mitigating against weather-related catastrophes and adapting to the long-term effects of climate change. For starters, when girls and women are better educated and included in decision making at all levels, their families and communities are more resilient and adaptable to economic and environmental shocks and

are better able to plan for, cope with, and rebound from climate crises. Data suggest that there is a strong positive association between the average amount of schooling a girl receives in her country and her country's score on indexes that measure vulnerability to climate-related disasters [54] (p. 5).

They propose a three-platform plan for resilience in the face of climate change [54] (p. 5): "(1) promoting girls' reproductive rights in order to ensure equitable climate action; (2) investing in girls' education in order to foster climate participation and leadership; and (3) spurring actions to develop girls' life skills for a green economy." Investing in girls' education to promote their environmental leadership may prove valuable as research demonstrates that women's participation in decision-making bodies leads to better protection of common property resources, among other benefits [7,8]. Educational attainment has additional quality of life benefits, improving economic growth, democracy, overall health, and life expectancy [55].

In most societies, better educated women and men have lower mortality rates and generally experience better mental and physical health and resilience [55]. Numerous reports demonstrate that improving women and girls' education reduces adolescent birth rates, child mortality, and fertility, which serve to simultaneously slow population growth and stimulate economic development by enhancing the rate of return to physical investment [21,22,59,60]. Moreover, research suggests that advancing girls' education has positive effects on the human capital of successive generations. Gains in women's educational attainment bolster their health knowledge, which leads to improvements in the health of their children [61]. In addition, women with higher levels of education have greater bargaining power with their spouses. Accordingly, their children experience better nutrition and health [62]. In sum, promoting women and girls' education not only improves their health and, if they have children, the health of their posterity, it also serves to improve the quality of economic development and climate mitigation and adaptation efforts.

1.5. Labor Force Participation

A growing body of economic literature has built off of Boserup's [23] and Waring's foundational work by examining the complex interplay between gender inequality and economic development [4,5]. This research has found that gender disadvantages in education, health, and the labor market are key factors influencing long-term economic growth, even if disparately. Research also demonstrates that economic development indicators—such as increasing GDP per capita—are positively correlated with environmental degradation, while other human development indicators—like access to education and increased life expectancy—show no relationship to environmental harm [11,12]. These findings suggest that development oriented toward improving quality of life, rather than GNP or GDP, and addressing issues of social inequality will better serve the stated goals of sustainable development, potentially decoupling the long-observed association between development and environmental change.

Increasing women's labor force participation has mixed effects on economic development and life expectancy, with results hinging on the characteristics of the nation and its position in the world system. These mixed results suggest that the type of labor force participation matters for development outcomes, and potentially for greenhouse gas emissions. Further, the type and quality of women's labor force participation matter for well-being, as occupation, income, and wealth are all associated with life expectancy [25,26]. Women all over the world are more likely than men to work in the least desired jobs with the lowest wages and little-to-no benefits or protections. Still, there are appreciable differences between and within developed countries (DCs) and LDCs, especially with regard to access to education—which considerably alters the array of accessible occupations and incomes [63]. Here, we look at differences in labor force participation between DCs and LDCs while also considering the heterogeneity in types of employment within DCs and LDCs.

Different types of labor force participation have different effects on life expectancy and well-being, as well as the environment, even in DCs. Women, especially women of

color, in the US are more likely than men to work in contingent jobs with lower wages and minimal benefits, and they are twice as likely to work part-time than men [64]. While women are more likely to experience poverty if they do not have access to education and employment, low-waged work with little-to-no benefits also affects their well-being. Specifically, low-income wage earners who live in low-income neighborhoods have the highest mortality rates in the U.S. regardless of race, but mortality rates are higher still for poor Black men and women [27]. Conversely, women working in well-paid, high prestige occupations live longer, marry later, and have fewer children [25,28]. The income gap in the US is correlated with a significant mortality gap as well, whereby "the gap in life expectancy between the richest 1% and poorest 1% of individuals was 14.6 years... for men and 10.1 years... for women" [65] (p. 2). Noting the importance of increased incomes on health outcomes, simply promoting workforce participation is not enough to improve women's living conditions.

Poor women, especially in LDCs, supply steady and cheap labor that reduce wages [36–38]. Indeed, utilitarian analysts argue that developing countries decrease their international competitiveness by restricting women's paid labor force participation because of increased average labor costs [20,66]. Women in LDCs are more likely to work in sweatshops that include two or more labor violations, and may experience long-hours, low-wages, unsafe working conditions, substandard housing, toxic environmental exposures, and sexual harassment or assault on the job [31,67,68]. For example, the export-oriented garment sector is a labor-intensive industry that requires little education and is often a first sector to expand in a developing economy [69]. Countries such as Bangladesh and Cambodia rely heavily on the garment industry as it represents 80 percent of their manufacturing exports [69]. Women are generally preferred in this type of employment because they work for much less than men, are thought to be more deferential, and have relatively "nimble" fingers. Ninety percent of Cambodia's garment industry workforce is made up of young, rural, migrant women [69]. In Korea, Malaysia, and Vietnam, young girls from rural areas make up "the majority of the labor force in light manufacturing, textiles, garments, shoes and electronics industries established in export-processing zones or in sweatshops in big cities" [70]. Similar gender compositions are found in maquiladoras in Northern Mexico, where women assemble electronics and textiles in hostile working conditions [67]. These conditions have shown to negatively affect workers' health, which may contribute to increased mortality [71]. Access to education is a key determinate of better employment opportunities for women, however, such access is still lagging in many developing nations [72,73].

Different types of employment also have qualitatively different environmental impacts. Specifically, export-oriented production of electronics poses distinct environmental threats that differ from "green" oriented jobs, such as home weatherization [74,75]. "Green" job development is one commonly suggested way to both grow the economy and improve environmental conditions [75]. Without diminishing the importance of such potential pathways to mitigation, we follow Waring in proffering that, by most indicators, the most heavily invested in sectors of the economy tend to be destructive of both the environment and human well-being [5]. When examining the distribution of value represented in the U.N.'s system of national accounts, Waring notes that it appears that "killing people, or being prepared to kill them, is considered very valuable" [5] (p. 136). Illustrative of her comments, the modern world's largest employers—such as national militaries, fast food, and petroleum corporations—tend to be among the most physically harmful and environmentally destructive, and thus the impact of green jobs is currently minimal [76]. The US military, for instance, is the largest employer in the world and is one of the world's biggest CO_2 emitters, emitting more than some industrialized nations [76,77]. While very little research breaks down the employment sector by gender and environmental harm, Marjorie Cohen's work provides an exception [74]. Cohen focuses on Canadian employment sectors, transportation, and household work. She finds that men are more likely to be employed in high emitting industries than women, such as electricity and fossil

fuel production, and men have much longer daily car commutes on average and are more likely to drive at all [74].

Some research exists that suggests that better working conditions may attenuate environmental harm. Nations with stronger labor unions, and subsequently better workers' health and safety regulations, tend to have reduced greenhouse gas emissions comparatively [78]. In addition, cross nationally both DCs and LDCs with longer working hours tend to consume more energy and emit more CO_2 [79]. Considering that highly feminized sweatshop labor in developing nations tends to be precarious work, with long hours and minimal adherence to workers' rights or safety precautions, it stands to reason that much of this work is environmentally hazardous as well. Consider the example of the garment industry; it uses many toxic chemicals and is a heavy polluter that has surpassed planetary boundaries for waste generation, energy emissions, and land use [80]. Conversely, industries employing an educated workforce, especially ones that are unionized, may more closely adhere to worker's safety, and thus environmentally benign working conditions. Women's employment opportunities also have disparate economic impacts, and those impacts may be associated with education as well as decision making access.

Taken together, the above research suggests that women's political empowerment and educational attainment serve to increase life expectancy and mitigate environmental harm. These two associations would suggest that improving these dimensions of gender equality will also tend to result in an improved CIWB, as reduced emissions and increased life expectancy would be suggestive of greater sustainability in general. However, effects of women's involvement in the labor force are further complicated by a variety of national level factors, including predominant industrial sectors, stage of development, and world systems position. Thus, different forms of gender equality may interact with other key variables to produce different environmental impacts. We turn to our data and methods to describe how we investigate these phenomena below.

1.6. Hypotheses

To summarize the above literature review, we are testing the following hypotheses (H1–H3) describing the proposed independent effects of the three dimensions of gender equality:

> As proportionately more women have political decision-making positions (H1), and have access to education (H2), the CIWB of a nation will go down. Conversely, considering that a good deal of women's labor opportunities globally are in fields associated with relatively higher mortality rates and CO_2 emissions, as proportionately more women participate in the labor force (H3) the CIWB will go up.

In order to explore the ties between the components of gender equality included in this analysis suggested by the literature reviewed above, we test the hypotheses outlined below (H4–H5), which incorporate interaction terms to examine the moderating effect that the three aspects of gender equality have on one another:

> As proportionately more women have political decision-making positions (H4), and have access to education (H5), the impact of women's participation in the labor force on CIWB will decline.

2. Materials and Methods

2.1. Data and Analytic Technique

To test our hypotheses, we utilize country-level information, integrating longitudinal data on socio-environmental variables from the UN [43] and the World Bank [81] for the years 1995 to 2013. The variables GDP per capita, urban population percentage, inflows of foreign direct investment as a percent of GDP, manufacturing as a percent of GDP, the percent of the population that is under 14, life expectancy at birth, and carbon dioxide emissions per capita were obtained from the World Bank's World Developmental Indicators website. They measure gross domestic product per capita in constant 2010 dollars, percent

of the population residing in urban settlements, percent of GDP attributable to foreign direct investment, percent of GDP attributable to manufacture, the age structure of the population, the average life expectancy of the population in a given year, and metric tons of CO_2 emitted per person, respectively. Life expectancy at birth and CO_2 emissions per capita are used in order to construct the dependent variable CIWB. GDP per capita is a primary independent variable of interest. Urban population size and foreign direct investment have been repeatedly found to be drivers of CO_2 emissions, and as a result we choose to control for them here.

Our gender inequality variables (share of parliament seats held by women, percent of women in the labor force, women's expected years of education) were obtained from the UNDP [43]. The data for the share of parliament seats held by women is compiled annually by the inter-parliamentary union, which collects data from national parliamentary websites. The data are made available through the UN as a disaggregated component of the Gender Inequality Index. The data consist of the percent of women in both upper/senate parliamentary roles as well as lower/house of representatives' parliamentary roles. The data for the labor force participation rate for women are compiled by the international labor organization and expresses women in the labor force as a percent of the working age population. The data for women's attainment of education measure the expected years of education for female children when entering school. Finally, the democracy data were obtained from the Polity Project [82] and use a range of 0 to 10 to measure the importance and strength of democratic processes within political regimes. Specifically, the democracy, or DEMOC, variable of the Polity Project measures the existence and strength of a nation's (1) democratic institutions and procedures, (2) mechanisms that serve to check the power of executives, and (3) the civil rights and liberties [82]. In order to avoid comparing nation's with fundamentally different political and ideological approaches to democratic practices and processes, we exclude nations with a democracy score of 0, which indicates that a nation shows no evidence of democratic processes or values.

2.2. CIWB

To construct our dependent variable, we employ World Bank, World Development Indicators, data on anthropogenic CO_2 emissions per capita and average life expectancy at time of birth within nations. We place anthropogenic CO_2 emissions per capita, which captures emissions from the burning of fossil fuels and the manufacture of cement measured in metric tons, as our numerator in the CIWB ratio. We use average life expectancy at birth as our denominator. Doing so enables us to examine the change in a nation's anthropogenically produced CO_2 emissions in relation to that nation's change in average life expectancy. To prevent changes in the CIWB ratio being driven solely by one component of the measure, we incorporate a constant into the numerator which renders the coefficients of variation for CO_2 emissions and life expectancy at birth equivalent to one another [83]. The following equation is used to calculate CIWB:

$$CIWB = [(CO_2 \text{ per capita} + 37.09)/\text{life expectancy at birth}] \times 100$$

CIWB's construction as a ratio calls for a particular interpretation of the outcomes presented in the analyses below. Two things should be kept in mind moving forward. First, as a result of CIWB's status as a ratio, it is possible that the associations it holds with the various independent variables examined here are the result of divergent associations between a predictor variable of interest and the numerator and denominator of CIWB. That is to say, a given predictor variable might have a differing association with emissions than it does with life expectancy at birth. What this ultimately suggests is that a particular value of CIWB, and as a result a particular sign and magnitude of the coefficient representing the association between a predictor and CIWB, can be the result of more than one set of social processes. Growth in the value of CIWB could be a function of increasing emissions and a stable life expectancy at birth, or of declining life expectancy coupled with a cessation in the growth of emissions—for example. However, the second consideration of note that we

draw readers attention to is that in either case the increase in CIWB would be representative of a decline in the years of life expectancy at birth that might be expected given a certain value of emissions. It is the responsiveness of such a dynamic to change in the various dimensions of gender equality that we are primarily interested in exploring here. Put simply, our analyses are constructed to explore how it is that change in women's rate of participation in the labor force, legislative processes, and the pursuit of formal education serves to change the expected relationship between CO_2 emission and the amount of time a population can expect to live. In this sense, CIWB is not fundamentally different from other ratio variables that are commonly included in sociological analyses, such as GDP per capita, population density, or energy use per capita. As with CIWB, growth in these ratios can be the result of a decline in the denominator relative to the numerator, or of growth in the numerator relative to the denominator. Yet, either path to growth in these ratios would be representative of, respectively: a larger economic output relative to population size; an increase in the size of the population in a given geographical area; and an increase in energy use relative to population size.

We nevertheless grasp the importance of gaining an understanding of the particular socioeconomic dynamics that lead to CIWB outcomes for both decision makers and researchers, as well as how it is that these dynamics might differ for more and LDCs. Thus, while our focus is on the association between the various dimensions of gender inequality and CIWB, we also include a replication of the analyses presented here where the dependent variables are set as the individual components of the CIWB ratio (i.e., CO_2 emissions per capita and life expectancy at birth). We discuss what the results of these additional analyses indicate for the patterns observed here below. The results of the additional analyses can be found in Tables S1–S4 of the Supplementary Materials. In addition, nations included in analyses and in LDC and DC classifications can be found in Table S5 of the Supplementary Materials.

2.3. Gender Equality

At the level of the nation-state, the concept of gender equality has become a very useful analytic tool for development scholars to assess variation in gender relations and human development across time and space [8,9]. Much of the data utilized in this research are published by organizations like the UN and the Organisation for Economic Co-operation and Development. Indeed, for the UN, gender disparities in human development outcomes, either implicitly or explicitly, constitute a large portion of the information used to construct various measures of overall human development. On the one hand, the Human Development Index (HDI) and the Inequality-adjusted Human Development Index (IHDI) incorporate life expectancy at birth, which is partly dependent on maternal health [84]; the same is true for child mortality, which is used in the Multidimensional Poverty Index (MPI). On the other hand, the Gender Development Index (GDI) and the GII both explicitly incorporate dimensions of gender disparity in their development measure. Thus, gender relations play a major role not only in the broader concept of development, but also in how it is operationalized and measured. For this research, we use the GII [43]—which measures reproductive health, empowerment, and the labor market participation—to estimate gender inequality in countries for which sufficient information is available. The GII measures can be broken down further, such that empowerment measures include proportion of parliamentary seats occupied by females and average years of educational attainment for females over 25 years of age. We are most interested in the effects of the proportion of parliamentary seats held by women, proportion of women that hold some secondary education, and proportion of adult women who participate in the labor force. Descriptive statistics for all variables of primary interest can be found in Table 1.

Table 1. Descriptive Statistics (*N* = 225).

Variables	Mean	Median	SD	Min.	Max.
CO_2 emissions (metric tons per capita)	6.43	5.71	4.88	0.07	29.42
Life expectancy at birth, total (years)	74.67	75.28	5.56	48.98	82.70
CIWB per capita	58.47	56.59	6.76	49.15	96.42
GDP per capita (constant 2010 US$)	21,899.68	11,938.28	21,908.51	233.14	103,588.60
Percent of legislators that are women	31.05	31.20	8.55	4.90	57.40
Women's expected years of schooling	14.79	15.10	2.39	5.60	21.00
Women's labor force participation (% of female population ages 15+)	51.17	51.30	9.09	23.09	84.59
Foreign direct investment (% of GDP)	5.54	3.26	7.90	0.13	73.53
Urban population (% of total)	65.79	67.96	17.42	9.90	97.69
Democracy score	8.73	9.00	1.94	1	10
Population ages 0–14 (% of total)	21.44	18.66	7.07	13.37	46.17
Manufacturing (% of GDP)	16.28	16.35	5.93	1.06	34.6

2.4. Analytic Technique

We constructed Prais-Winsten regression models with panel-corrected standard errors (PCSE), allowing for disturbances that are heteroskedastic and contemporaneously correlated across panels. We use nations as our unit of analysis and include year and country specific intercepts to control for potential heterogeneity that is temporally invariant within nations, and cross-sectionally invariant in time periods. Additionally, we correct for AR (1) disturbances within panels, treating the AR (1) process as common to all panels because there is no theoretical reason to assume the process is panel specific. These procedures are beneficial to the study at hand, as the use of fixed effect estimators acts to control for nation specific characteristics that might influence outcomes but are not easily measurable—such as particularities of a nation's geographical and geological advantages—as well as for phenomena specific to a particular time period that may influence many units simultaneously—such as fluctuations in the average costs of energy. The result is that the majority of variance accounted for in the models presented below is attributable to fixed effects estimators, and correlational hypothesis testing is conservative. Additionally, correcting for AR (1)—first order autocorrelation—accounts for the correlation of residuals from one year to the next. Accounting for such phenomena is useful as many social processes are temporally correlated in ways that are difficult to capture in statistical models, which can result in a violation of the assumption of independence in the distribution of residuals. Use of the "xtserial" command in Stata 15.1– from StataCorp of College Station, Texas, USA– suggested that autocorrelation was present in our data, while the "xttest3" command indicated the presence of heteroskedasticity. We carry out our analyses using the "xtpcse" command in Stata 15.1.

In order to explore the ways in which women's access to political decision-making positions and education moderate the association between women's participation in the labor force and CIWB, we again employ PCSE regression with corrections for AR (1) disturbances and also incorporate interaction terms between access to education and participation in the labor force, and number of legislative seats held and labor force participation in separate models. Finally, in order to gain further insight into the mechanisms driving change in CIWB found to be associated with the gender equality variables, we replicate the analyses described above using emissions per capita and life expectancy at birth as dependent variables in isolation of one another. Doing so grants us insight into how it is that these dynamics come to bear in both LDCs and DCs. The results of the analyses performed on the independent measures of CO_2 emissions per capita and life expectancy at birth can be

viewed in the Supplementary Materials but are discussed and considered along with all other results below.

3. Results

Results of the analyses using CIWB as the dependent variable can be found in Tables 2 and 3. Table 2 displays analyses exploring the direct effect of three of the primary components of the GII—percent of legislative seats held by women, expected years of education for women, and the percent of women active in the labor force—on CIWB (Here, we make two comments to address the topic of multicollinearity in our regression results. First, there are seven waves of data used for the longitudinal analysis in Model 1 of Table 2. To estimate variance inflation factors (VIFs) for this panel model, we ran seven cross-sectional OLS regression analyses, one for each wave of data. From these seven OLS models, the average maximum VIF was 7.38, which is below the conventional threshold of concern- 10. Second, while we report the VIF for this model in Table 2, the models in Table 3 include interaction terms. As Allison notes, while the VIFs in a model with interaction terms will be high, this multicollinearity will have no adverse effect on the *p*-values of the variable and its interaction terms [85]). Before continuing, we note that CIWB is an expression of the relationship between two variables that are of interest to scholars of sustainability studies. Those variables are pollution—here represented by CO_2 emissions per capita—and well-being—operationalized here as average life expectancy at birth. A change in the value of CIWB represents a change in the way that these two variables of interest relate to one other. Thus, substantively, positive percentage changes in CIWB should be interpreted an overall increase in the "intensity" with which CO_2 must be emitted in order to maintain a given level of life-expectancy. For instance, an increase of 0.2% in CIWB suggests that average emissions per capita have increased by 0.2% relative gains in life expectancy. Conversely, a 0.2% decrease in CIWB would suggest that life expectancy has increased by 0.2% relative to carbon dioxide emissions per capita—the more desirable of the two outcomes. Put differently, increasing CIWB is associated with an average loss of ground in efforts to achieve UN SDGs 3 and 13. On the other hand, a decrease in CIWB suggests that we are making progress towards achieving both of these critical goals.

Across all nations, our findings indicate that increases in both the percent of legislative seats held by women and the years of education women obtain serve to reduce the ratio of CO_2 emitted per year of life expectancy at birth. We find that across all nations a 1 percent increase in the percent of legislative seats held by women is expected to reduce CIWB by 0.01 percent, while increasing women's expected educational attainment by 1 percent is associated with a 0.07 percent reduction in CIWB. Conversely, it appears that, across all nations, increasing the percent of women participating in the labor force by 1 percent is associated with an increase in CIWB of 0.083 percent, on average. Finally, a 1 percent increase in GDP per capita should be expected to increase the CIWB by 0.085 percent, a result that remains stable across all models presented here and is consistent with the results of previous research exploring the impact of economic development on the CIWB [3]. The control variables urban population percentage, inflows of foreign direct investment as a percent of GDP, manufacturing as a percent of GDP, the percent of the population that is under 14 were, for the most part, found not to have a meaningful association with CIWB. The exception is the negative association between urbanization and CIWB in DCs. As with the association of GDP per capita, this association is to be expected considering what is suggested by the literature [17].

Table 2. Prais-Winsten regression models influences on carbon intensity of well-being.

Independent Variables	All Nations	DCs	LDCs
Percent of female legislators	−0.019 ***	−0.002	−0.019 *
	(0.016)	(0.011)	(0.008)
Expected years of schooling for women	−0.065 *	−0.119 **	0.023
	(0.026)	(0.034)	(0.069)
Percent of women in the labor force (ages 15+)	0.083 **	0.086 *	0.101 *
	(0.104)	(0.043)	(0.026)
GDP per capita	0.085 ***	0.112 ***	0.056
	(0.071)	(0.024)	(0.032)
Foreign direct investment	0.000	0.002	−0.003
	(0.001)	(0.001)	(0.301)
Percent urban population	−0.111	−0.320 *	−0.142
	(0.083)	(0.128)	(0.438)
Percent population 0–14	−0.035	0.044	−0.141
	(0.143)	(0.047)	(0.076)
Democracy	−0.018	−0.054	0.022
	(0.131)	(0.030)	(0.064)
Percent of GDP from manufacturing	−0.018	−0.030	−0.066
	(0.158)	(0.026)	(0.037)
R-squared [1]	0.999	0.998	0.989
Nations/total N	70/225	34/130	36/95

Notes: *** $p < 0.001$ ** $p < 0.01$ * $p < 0.05$ (two-tailed tests); Standard errors in parentheses. [1] Readers may note that the R^2 values of all models are relatively high (e.g., above 0.98). We caution readers against using these R^2 values in order to determine the relative importance of variables added and removed from models. The PCSE modeling approach with fixed effect estimators for nation and year is designed to account for both contemporaneous and extemporaneous drivers of change in the dependent variable. The result is that the largest share of dependent variable variance is accounted for by model structure. In null models where no predictor variables were included, otherwise identical to those presented here, R^2 values were consistently above 0.97—for instance.

We find notable changes in the associations when examining the same relationships in nations that fall under the UN's DCs classification. For example, across DCs the relationship between change in the percent of legislative seats held by women and CIWB that is statistically distinguishable from 0. As with analyses on all nations, increasing the percent of women active in the labor force is associated with increases in CIWB, when limiting analyses to DCs. Our findings suggest that there is a negative and significant relationship between women's average years of education and CWIB in DCs. What is more, this relationship appears to be of a notably greater magnitude in DCs than it does across all nations. Our findings indicate that among DCs a 1 percent increase in the expected educational attainment of women is associated with a 0.119 percent decrease in CIWB.

Analysis of the relationship between three components of gender inequality employed here, and CIWB in LDCs reveals results that are strikingly different than those yielded by analyses of DCs. While in DCs a 1 percent increase in the percent of legislative positions held by women did not have a statistically significant impact on CIWB, in LDCs the same change is estimated to reduce CIWB by 0.019 percent. Additionally, in LDCs a 1 percent increase in women's participation in the labor force is correlated with a 0.101 percent increase in CIWB. Finally, whereas expected years of education for women was a statistically significant indicator of gender equality in DCs, in LDCs a 1 percent increase in women's educational attainment does not have a statistically significant association with CIWB.

Exploring the results of such analyses on a disaggregated CIWB measure—that is, in models where associations with life expectancy at birth and emissions per capita are assessed independently of one another—offers some nuance to the results presented in Table 2. For instance, we find that, while the percent of women in legislative seats is negatively associated with a reduction in emissions, it has no association with life expectancy at birth. This finding indicates that the association between CIWB and percent of legislative seats held by women is a result of women's participation in decision making processes typically being negatively correlated with emissions. In contrast, the association between women's educational attainment and CIWB seems to be primarily a function of

education's association with simultaneous changes in life expectancy at birth and emissions per capita. That is to say, women's education is not found to have a significant association with emissions per capita or life expectancy at birth independently of one another, but it does seem to impact the way these two measures relate to one another, tending to result in the numerator—CO_2 emissions per capita—shrinking in relation to the denominator—life expectancy at birth—in a way that is statistically meaningful. Finally, across all nations we find that the positive association between CIWB and women's labor force participation rate is most likely a result of the tendency for women's participation in the formal labor market to result in reductions in life expectancy at birth—as it does not appear to have a statistically significant relationship with emissions per capita.

Table 3. PCSE models of influences on carbon intensity of well-being.

Independent Variables	All Nations-Model 1	All Nations-Model 2	DCs-Model 3	DCs-Model 4	LDCs-Model 5	LDCs-Model 6
Percent female legislators	0.180 **	−0.012 **	−0.225	−0.009	0.449 ***	−0.018 **
	(0.086)	(0.004)	(0.242)	(0.010)	(0.117)	(0.006)
Women's education	−0.079 **	0.994 ***	−0.108 **	2.105 **	−0.24	1.587 ***
	(0.026)	(0.118)	(0.034)	(0.628)	(0.060)	(0.296)
Women in the labor force	0.231 ***	0.722 ***	−0.095	1.621 ***	0.455 ***	1.056 ***
	(0.350)	(0.075)	(0.208)	(0.444)	(0.107)	(0.296)
GDP per capita	0.086 ***	0.102 ***	0.107 ***	0.117 ***	0.077 **	0.134 ***
	(0.015)	(0.014)	(0.023)	(0.023)	(0.029)	(0.031)
Foreign direct investment	0.000	0.000	0.002	0.003	0.000	−0.003
	(0.001)	(0.001)	(0.001)	(0.001)	(0.010)	(0.002)
Percent urban population	0.095	−0.067	−0.324 **	−0.263 *	−0.031	0.045
	(0.152)	(0.061)	(0.125)	(0.124)	(0.071)	(0.052)
Percent age 0–14	−0.039	−0.001	0.036	0.053	−0.115	−0.048
	(0.031)	(0.028)	(0.046)	(0.045)	(0.011)	(.055)
Democracy	−0.023 *	−0.017	−0.056	0.047	−0.027 *	−0.0023 *
	(0.011)	(0.012)	(0.031)	(0.027)	(0.011)	(0.009)
Percent of GDP (manufacturing)	−0.021	−0.025	−0.033	−0.016	−0.015	−0.019
	(0.013)	(0.013)	(0.028)	(0.026)	(0.011)	(0.011)
Legislators x labor force	−0.048 *	-	0.057	-	−0.116 ***	-
	(0.021)		(0.367)		(0.029)	
Education x labor force	-	−0.256 ***	–	−0.574 ***	-	−0.404 ***
		(0.031)		(0.163)		(0.067)
R-squared	0.998	0.999	0.998	0.987	0.992	0.998
Nations/total *N*	70/225	70/225	34/130	34/130	36/95	36/95

Notes: *** $p < 0.001$ ** $p < 0.01$ * $p < 0.05$ (two-tailed tests); Standard errors in parentheses.

Exploring these more fundamental associations grants greater insight into the observed differences in the associations between our measures of gender equality and CIWB across the LDC and DC classifications as well. This is especially true when it comes to understanding the unique associations found in the analysis of DCs. For instance, women's political participation seems to be more impactful for emissions outcomes than those associated with life expectancy at birth, but that association is not significant among DCs. The result is that, for such nations, increasing the relative proportion of women holding legislative seats does not result in a decline in emissions, and thus has little or no bearing on the ratio of emissions to life expectancy—CIWB. However, for such nations we also find that increases in the average years of education attained by women both reduces emissions and increases life expectancy at birth. The result is that in DCs, increasing women's educational attainment is a particularly effective way to reduce CIWB—or improve the efficiency with which natural resources are converted to social well-being. On the other hand, we see that in LDCs, as is true across all nations, percent of women holding legislative seats has a

direct, negative association with emissions, but bears no relationship with life expectancy at birth. This ultimately indicates that increasing the decision-making power of women in LDCs serves to improve environmental conditions, but not necessarily life expectancy at birth. Additionally, as is the case across all nations, increasing the percent of women who are active in the labor force seems to result in reductions in life expectancy across LDCs, but not in any significant change in emissions. These results suggest that, while more DCs would benefit most from policies that further women's education, LDCs might benefit greatly from policies aimed at both improving women's educational prospects and at implementing labor protections that safeguard the health of women joining the workforce. The results for analyses on the independent components of CIWB can be viewed in Tables S1 and S2.

It is often the case that components of gender inequality change concurrently and that the various aspects of gender equality likely have an impact on the form that each other takes. For example, it is likely that the average level of women's education and the number of women in positions of legislative power impact the ways in which women participate in the workforce. In Table 3, we examine how components of gender equality moderate each other's relationship with CIWB. As with the analyses presented in Table 2, we explore how such moderation varies among LDCs, DCs, and all nations. Additionally, we replicate these models on the two components of CIWB independently. The results can be viewed in Tables S3 and S4 of the Supplementary Materials.

In Table 3, Model 1, we explore how the percent of legislative positions held by women moderates the relationship between the percent of women in the labor force and CIWB. Our findings indicate that, though the main effect of both percent of legislative seats held by women and percent of women active in the labor force are positive, the interaction between the two is both significant and negative. This finding suggests that, across all nations, increasing the percent of women with positions in the legislature by 1 percent is associated with a reduction in the impact that increases in women's participation in the labor force has on CIWB. Model 2 demonstrates that a similar set of associations exist for the relationships between women's education, women's participation in the labor force, and CIWB. Exploration of these interactions in DCs and LDCs indicates that such associations remain fairly consistent across all nation groupings explored here. The exception to this consistency is the interaction between the percent of legislative seats held by women and the percent of women active in the labor force in DCs (Model 3), where we found that there is no significant interaction between these two aspects of gender equality.

Exploration of the moderating associations between women's percent of legislative seats, women's educational attainment, and women's labor force participation for life expectancy at birth and emissions per capita allows for greater nuance to be incorporated into this discussion. Again, we find that, across all nations, increasing the percent of women holding legislative seats reduces the impact that women's labor force participation has on emissions, while also yielding an increasingly positive association with women's labor force participation and life expectancy. This suggests that, across all nations, while increasing labor force participation tends to increase emissions, and reduce life expectancy—leading to overall increases in CIWB—these impacts are attenuated in nations that include women in political decision-making processes. We note that, while these results remain consistent for LDCs, as is the case in Table 3, in more DCs, women's participation in legislative processes does not moderate the associations between women's labor force participation and emissions or life expectancy.

Similarly, we find that across all nations increasing women's educational attainment does not moderate the association between CO_2 emissions per capita and women's labor force participation. Yet, such a moderation does exist for the association between women's education, women's labor force participation, and life expectancy at birth. Specifically, we find that women's labor force participation is negatively associated with life expectancy at birth across all nations, but that the association is attenuated—or made to be more

positive—in social contexts where women are more involved in secondary and post-secondary education. These results remain consistent when analyses are limited to LDCs.

As is the case in the results presented in Table 3, in Tables S3 and S4 we find that in DCs increasing women's educational attainment has a double benefit for CIWB. Among DCs, we find that countries with a higher women's educational attainment value see the association between women's labor force participation and emissions reduced (i.e., made to be less positive), even as the association between women's labor force participation and life expectancy is increased (i.e., made to be more positive).

Considering the consistency of the results presented in Table 3, as well as the consistency of the results presented in the Supplementary Materials, here we focus the remainder of our analytical discussion on the moderating effect of the three components of gender inequality across all nations. To aid in the discussion of these results, graphic representations of Models 1 and 2 of Table 3 are presented in Figures 1 and 2 below.
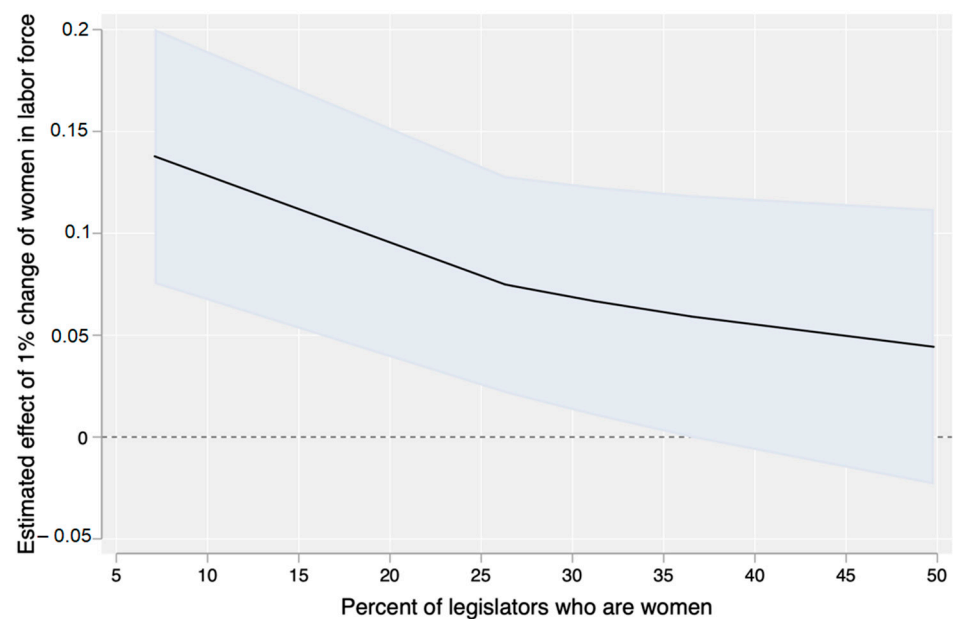
Figure 1. Estimated coefficient of women in the labor force conditioned on women legislators. Caption: Figure 1 displays the estimated percentage effect of a 1% change in women's participation in the labor force on CIWB. Shaded area represents 95% confidence intervals. Increasing the percent of women holding legislative seats reduces the magnitude of the relationship between the number of women in the labor force and CIWB. However, we note that beyond roughly 36.4% (indicated by the dashed horizontal line's intersection with the shaded region) of legislative positions being held by women the relationship between women's participation in the labor force and CIWB is no longer statistically significant.

Figure 1 displays the interaction between women's labor force presence and women's presence in the legislature across all nations. Examination of Figure 1 demonstrates that when percent of women holding legislative positions is relatively low, the association between women's labor force participation and CIWB is at its highest. Increasing the percent of positions in legislative bodies that are held by women, however, notably reduces the association between CIWB and increases in the percent of women in the labor force. The association between labor force participation and CIWB continues to decline as the percent of legislative seats held by women increases until the percent of legislative seats held by women reaches 36.4% (the 74th percentile) at which point the association between women's labor force participation and CIWB is no longer statistically significant. This suggests two things, the first is that if a nation was to move from the minimum value of labor force participation (23.09%) to the maximum value (84.59%), while women's participation in the legislature was held at the minimum observed value of 4.9% then we should expect CIWB

to increase by roughly 9.6%—suggesting that the carbon cost of life expectancy is notably increased. If, however, the nation has a more gender equal political representation then this impact is greatly diminished, such that beyond 36.4% of women's representation there is no statistical impact on CIWB associated with the financial empowerment of women.
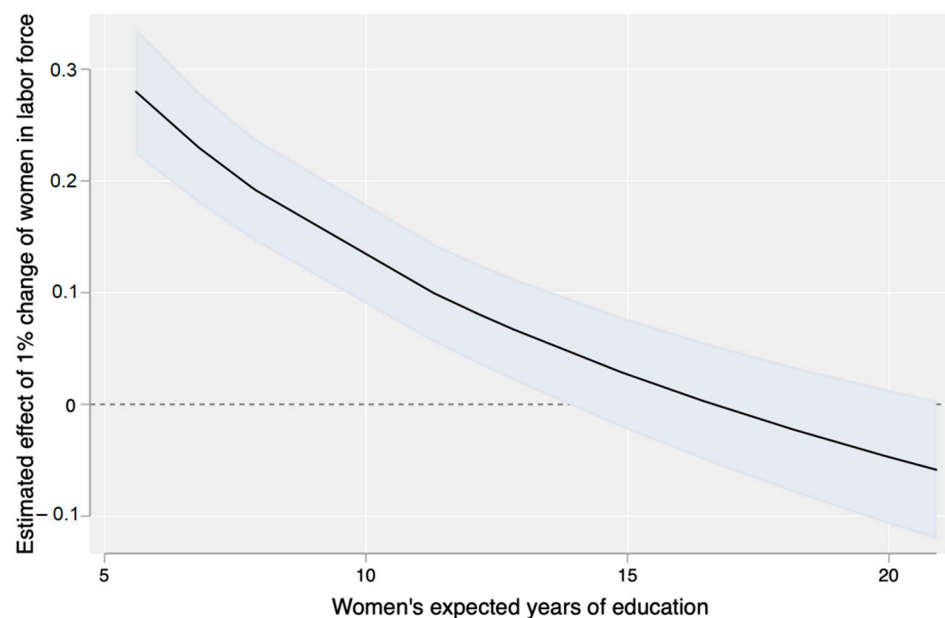
Figure 2. Estimated coefficient of women in the labor force conditioned on women's education. Caption: Figure 2 displays the estimated relationship between women's participation in the labor force and CIWB as moderated by the expected years of education women will hold at the national level. Shaded area represents 95% confidence intervals. As the number of years women are educated increases, the effect of women's participation in the workforce on CIWB declines substantially. Beyond about 13.84 years of education (marked by the dashed horizontal line's intersection with the shaded region) the relationship between women's participation in the labor force and CIWB is no longer statistically significant.

Figure 2 displays the moderation of the relationship between women's participation in the labor force and CIWB by expected years of women's education among all nations. As with Figure 1, Figure 2 suggests that increasing the average years of educational attainment held by women substantially reduces the impact that women's labor force participation has on CIWB. As our results in Tables S3 and S4 of the Supplementary Materials demonstrate, this association is driven by the tendency for nations with higher levels of women's educational attainment to have a relatively positive association between women's labor force participation and life expectancy at birth. Here, however, we note that the moderation of the association between women's labor force presence and CIWB by women's educational attainment continues until about 13.84 years of education is reached (the 37th percentile of women's education), at which point the relationship between the percent of women active in the labor force and CIWB is no longer significant. Put differently, if a nation was to move from the minimum value of labor force participation (23.09%) to the maximum value (84.59%), while women's educational attainment was held at the minimum observed value of 5.6 years then we should expect CIWB to increase by roughly 17.20%—suggesting that the carbon cost of life expectancy is substantially increased. If, however, the nation has a more gender equal educational outcomes then this impact is greatly diminished, such that beyond 13.84 years of women's education there is no statistical impact on CIWB associated with women's participation in the labor force. horizontal dashed line's intersection with the shaded region) the relationship between labor force participation and CIWB is not statistically different from 0.

4. Discussion and Conclusions

In this study, we build upon prior environmental sociological research that understands gender equality as a socio-structural factor that is more or less uniform in its constitution [8] or is best understood as an aggregation of many interrelated components of social life which have consonant impacts on socio-ecological outcomes [9]. However, drawing from a number of works concerning the relationship between gender equality, CO_2 emissions, life expectancy, economic activities, and myriad other aspects of social life, we depart from previous work in theorizing that gender equality is not only a multi-dimensional social structure, but that each dimension of this complex structure may impact social and environmental spaces in unique ways. Similarly, we note that the various constituents of the social world that contribute to the presence or absence of gender equality are deeply interrelated. As a result, it is likely that a change in any single dimension of gender equality will modify the way the others relate to socio-ecological processes. We argue that one implication of this complexity is that the achievement of gender equality across numerous dimensions is not only of benefit to women, but also creates greater space to simultaneously improve wellbeing while drawing down the carbon intensity of social processes.

The purpose of looking at different components of gender equality is to assess the types of gender development that are most advantageous to women and the environment. We find that the type of development matters for both environmental and social outcomes. Specifically, for the models that include all nations, increasing gender empowerment, which includes both the percent of legislative seats held by women and their years of educational attainment, serves to reduce the ratio of CO_2 emitted per year of life expectancy at birth. Thus, generally enhancing women's empowerment also serves to lessen this harmful environmental impact relative to the social good it yields. The results further suggest that women's educational attainment is associated with both reduced emissions and increased life expectancy, which are in line with previous research, explored above, showing a positive relationship between education attainment and life expectancy as well as environmental resilience [54,55]. Our results look a bit different when we focus on DCs versus LDCs. For instance, they indicate that in more DCs the percent of women holding legislative seats does not offer the same environmental benefit as it does in LDCs and across all nations.

However, across all nations—and in LDCs in particular—increasing the percent of women participating in the labor force is associated with an increase in CIWB. Thus, increasing labor force participation, and potentially creating more exploitative and unequal labor relations, correlates with a declining conversion of environmental exploitation into social well-being. The dimensions of gender inequality are not entirely independent of one another, however, and serve to moderate each other's associations with CIWB. Increasing women's educational attainment and seats in parliament attenuate the relationship between the percent of women in the labor force and CIWB, both across all nations but particularly in LDCs.

The finding that increasing women's labor force participation increases the CIWB, especially in LDCs, is interesting and calls for comment. Considering the power dynamics of the world system and the problem of unequal exchange across as well as within nations', the least desirable work falls on the most disadvantaged groups of people [86]. As noted in the literature review, women around the world make up the poorest and least educated groups of people with the least political decision-making power and access to resources [28]. In developing countries, women often make up the majority of sweatshop laborers in textiles and electronics manufacturing [71]. This has led some commentators to refer to this phenomenon as the "feminization of globalization" or labor [87]. Women are hired for these jobs because of their presumed agility and docility, in that they will accept the lowest wages and worst working conditions with little-to-no complaint or resistance. While women workers do organize and resist, these sexist assumptions about women workers persist [88]. Export manufacturing of textiles and electronics or processing of electronic waste, among others, generally degrade the environment with emissions, toxins, and waste

byproducts. Workers exposed to waste or manufacturing byproducts also may experience physical health consequences [71]. While our data do not show these relationships explicitly, an ample body of research explores issues of unequal exchange [13,86] and gender and development [37,71,87]. Indeed, our findings generally support these theoretical and empirical claims, as they demonstrate that the most direct impact of women's participation in the workforce on CIWB is its association with reduced life expectancy across all nations. Considering as much, we believe that future research into the mechanisms that underlie the relationship between gender, unequal exchange, and CIWB may also prove fruitful.

The above results suggest that the different components of gender equality have variable effects on CO_2 emissions, life expectancy at birth, and their relation to one another such that nation and position in the geopolitical field interact with women's empowerment and employment to create disparate outcomes. Thus, targeting gender developments particular to nations, and their political and economic circumstance (SDG 5), is an important consideration for sustainable development. As previous research suggests, and our work shows, empowering women is generative of both social and environmental benefits. In the case of LDCs, the form of women's empowerment that most meaningfully impacts CIWB, and the related measures of life expectancy and emissions, is that of including women in legislative bodies and processes. While a focus on women's education is most beneficial in the case of more DCs.

In sum, our findings suggest that if we can increase the quality of human development, especially in regard to gender equality, rather than focusing on growth of GDP per capita, then we can mitigate our impact on the climate and improve human well-being. These findings corroborate other research that demonstrates the mutually beneficial relationship between different forms of equality and environmental quality. Future research should continue to parse out the mechanisms of different aspects of inequality—based on race, class, and nation, among others, as well as their intersections—that affect environmental outcomes.

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