Women in Power: The Role of Gender in Renewable Energy Policymaking

Mriga Bansal* and Natalia D'Agosti†

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Abstract

Do female policy makers encourage the production and investment of renewable energy compared to their male counterparts? Using instrumental variables, we conduct a cross-country analysis of 41 high-income countries for the years 1990 and 1997-2015 using quota laws and women's suffrage as instruments for women's participation in the parliament. We find that a 1 percentage point increase in the proportion of women in the legislature increases renewable energy production between 0.74 and 1.64 percentage points. This study suggests that fostering policies that boost women's participation in policy-making positions is beneficial, especially when considering the positive spillover to other countries.

Keywords: Female political representation, energy economics, climate change

*Rutgers University; mb1712@economics.rutgers.edu
†Rutgers University, nld59@economics.rutgers.edu
Address: 75 Hamilton St, Room 202, New Brunswick, NJ 08901

1 Introduction

Recently, there has been an increase in the representation of females in the political field. In 2019, the proportion of women in the national legislature worldwide was 24.64% (WBI.a, 2020). Research has shown that different policy outcomes emerge in a society depending on the gender of the legislators; women favor their gender the most (Besley & Case, 2003; Chattopadhyay & Duflo, 2004; Clots-Figueras, 2011; Weeks, 2019). Research also shows that women choose lower risk levels than men and know and care more about the environment (Xiao & McCright, 2012; Funk & Gathmann, 2015; McCright, 2010). Additionally, female legislators provide more public goods and support environmental policies more (Duflo et al., 2004; Fredriksson & Wang, 2011; Pearl-Martinez, 2014; Mavisakalyan & Tarverdi, 2019; Norgaard & York, 2005). There is evidence showing that governments are among the main contributors to the rapid deployment of renewable energy around the world through the introduction of different laws and policies (Adelaja et al., 2010; Crossley, 2019; Johnstone et al., 2010; Kilinc-Ata, 2016; Shrimali & Kniefel, 2011). Therefore, legislator's gender influences the implementation of environmental policies.

This study investigates whether the legislator's gender has an impact on the production of renewable energy. We conduct a cross-country analysis of 41 high-income countries for the years 1990 and 1997 to 2015. The adoption of renewable energy and the election of women to offices have an unclear causal relationship. Do female legislators pass more laws related to environmental protection, or are countries more likely to elect female legislators intrinsically more progressive? To circumvent this issue, we create a panel data with country and year fixed effects and instrument the endogenous variable, that is, the percentage of female legislators. We use passing a quota law and the number of years since women's suffrage in the country as instruments for the analysis. The results support the hypothesis that females in the legislature encourage the production of renewable energy. Using two different sets of instruments, we find that a 1 percentage point increase in the proportion of

women in parliament increases the production of renewable energy between 0.74 and 1.64 percentage points, after controlling for a rich set of variables.

A plausible concern is that the instrument may not be exogenous. Therefore, we test whether there is an anticipatory or placebo effect either by changing the quota law by two or four years or by making it random. Further, to allow for serial correlation within countries, we cluster the error term at the country level, reducing the sample to 41 clusters. Consequently, we adjust the standard errors using the wild bootstrap (Cameron et al., 2008). We also test the robustness of our results by dropping each country at a time, and find that they are still significant and close to the main estimation. Finally, our results remain unchanged after expanding the analysis to include Brazil, China, India, Indonesia, Mexico, the Philippines, South Africa, Thailand, and Turkey. These countries account for 96.11% of all renewable energy produced worldwide without hydro-power (Ritchie, 2017).

This study contributes to the literature in several ways. First, it contributes to the literature on the impact of female legislators on the large-scale production of renewable energy, a public good (Pearl-Martinez (2014)). Second, decarbonizing the economy through large-scale renewable energy production is key to mitigating climate change and can be performed more rapidly than in other sectors (Pachauri et al., 2014). Thus, we show evidence that promoting the election of females in the legislature could produce and accelerate this positive externality. Nevertheless, caution must be exercised if these results are extrapolated to other countries. High-income countries are intrinsically different from middle and low-income countries. Finally, our project extends the literature on cross-country analyses that link the presence of females in the legislature with more humanitarian military interventions (Shea & Christian, 2017), stricter climate change policies (Mavisakalyan & Tarverdi, 2019), lower CO_2 emissions (Ergas & York, 2012), more protected areas (Pearl-Martinez, 2014), more environmental agreements (Norgaard & York, 2005), higher health-expenditure by governments (Clayton & Zetterberg, 2018), more childcare expenditure policies (Weeks, 2019), and less corruption

and bribe acceptance (Dollar et al., 2001; Swamy et al., 2001).[1]

The remainder of this paper is organized as follows. Sections 2 and 3 describe the relationship between the percentage of female legislators and renewable energy production. Section 4 presents the data and descriptive statistics. Section 5 describes the econometric analysis. Sections 6 and 7 present the estimation results and robustness checks, respectively. Finally, we present our conclusions in Section 8, adding possible future research opportunities.

2 Energy and the Government

Fossil fuel combustion and industrial processes accounted for 78% of the total CO_2 emissions for the period 2000-2010 (Pachauri et al., 2014). The *Renewable Global Status Report* (Raturi, 2019) established that 74 countries committed to having some percentage of their energy production based solely on renewable sources.

Figure 1 and 2 illustrate the evolution of (average) renewable energy production over time for all countries around the world and high-income countries, respectively. Figure 1 shows that the production of renewable energy across all countries spiked in 1994, fell until 2006, and increased steadily thereafter. In high-income countries, renewable energy production was initially erratic but, skyrocketed after 2005. Thus, low-income and middle-income countries drove most of the growth in renewable energy production between 1990-2005, while high-income countries took the lead from 2005 onward.

Several studies using different samples, time spans, and policies conclude that governments around the world, pushing for regulatory policies and fiscal incentives, are the main drivers for the rapid increase in renewable energy production in the world. Regulatory policies include feed-in-tariffs (FITs), electric quota obligations (also known as renewable portfolio standards), net metering, and tendering (Raturi, 2019). Fiscal policies include investments,

[1] Find a summary of these papers in Table 10 in the Appendix.

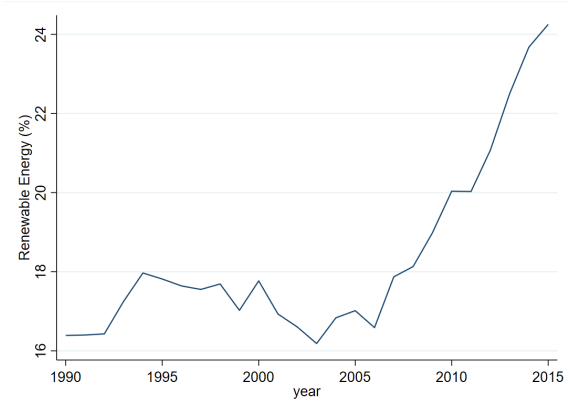


Figure 1: Percentage of renewable energy production for all countries. Source: WBI.b (2020)

Figure 2: Percentage of renewable energy production for High-income countries. Source: WBI.b (2020)

tax incentives, and public financing, such as public investments, loans, grants, and capital subsidies. For example, Crossley (2019) gathered legislation from 113 countries that promote renewable energy production. The author found that countries have passed these laws for several reasons. For example, 37 countries state as an objective in their renewable energy laws to promote sustainable development; 35 countries state as an objective the reduction of fossil fuel use and the reduction of oil dependency from other countries (Huang, Alavalapati, Carter, & Langholtz, 2007); 55 countries declare as an objective the protection of the environment; and 24 countries have laws supporting the expansion of the renewable energy production industry *per se*. Johnstone et al. (2010) conducted a panel data analysis of 25 OECD countries over the period 1978-2003. The authors analyzed the effect of several public policies have on renewable energy innovation, using patent counts as a proxy for innovation.[2] They concluded that public policy is a major contributor to renewable energy innovation. Furthermore, Adelaja et al. (2010) and Kilinc-Ata (2016) reached the same conclusion; Adelaja et al. (2010) studied the wind energy market in the United States, while Kilinc-Ata (2016) conducted a cross-country analysis for 27 countries of the EU and the United States. Similarly, Shrimali and Kniefel (2011) showed that different policies (RPS,

[2]Wind, solar, ocean, geothermal, biomass, and waste.

State Government Green Power Purchasing, and Clean Energy Fund) play an important role in the deployment of renewable energy production in the United States.

In 2019, 43 countries used tax credits as a stimulus, and 101 countries used public financing (Raturi, 2019). By conducting a cross-country analysis of 27 countries in the EU and the United States for a span of 18 years from 1990 to 2018, Kilinc-Ata (2016) found that feed-in-tariffs and tax policies help the deployment of renewable energy production. Similarly, Liu et al. (2019) conducted a cross-country analysis of 29 countries from 2000 to 2015 and concluded that fiscal and financial incentives, market-based instruments, policy and support, and RD&D improve renewable energy deployment. Finally, Shrimali and Jenner (2013) conducted a cross-state analysis for the United States over the years 1998-2009, finding that tax credits, among other policies, increase the production of solar photovoltaic power by reducing its costs.

3 Previous literature on female leaders

As remarked by Hessami and da Fonseca (2020), the literature has moved from the idea of politicians "just" reflecting the median voter preferences to continue in their seats, to a more accepted idea that some characteristics of the politician, such as gender and race, matter when implementing policies. In the same vein, using League of Conservation Voters data for the period 1970-1995, Fredriksson and Wang (2011) show that voters do not "affect" environmental policies pushing them to the middle. Instead, voters "elect" politicians who are aligned with their preferences and concerns, opposing the median voter theory. Research has found that women are more likely than men to provide public goods, favor their own gender, and push for policies that represent their own gender preferences the most (Chattopadhyay & Duflo, 2004; Clots-Figueras, 2011; Weeks, 2019). For example, Besley and Case (2003) analyze whether women legislators prioritize policies different from those of men in the USA

and find that women in power positions pass more laws regarding family assistance and child support.

A broad body of literature finds that female legislators seek to protect the environment. For example, in the Human Development Report, Pearl-Martinez (2014) used a sample of 90 countries and found that countries with a higher percentage of women in parliament are correlated with more protected land areas. Mavisakalyan and Tarverdi (2019) use a panel of 91 countries for the period 2005-2012 and find that more female representation in parliament leads to stricter climate change policies and a reduction in CO2 emissions. Norgaard and York (2005) studied 130 countries and found that more women in parliament are more likely to ratify environmental treaties. Similarly, (Fredriksson & Wang, 2011), using The League of Conservation Voters, found that female legislators push for stricter environmental policies.

Finally, research has shown that women care more about the environment. McCright (2010) used the Gallup survey from 2001 to 2008 and found that women manifest more concern and have more knowledge about climate change than men do. Similarly, Xiao and McCright (2012), using the Gallup survey, found that women care more about health problems caused by changes in the environment. The authors showed that this greater concern is due to women having different risk perceptions than men do. Moreover, Funk and Gathmann (2015) studied the differences between men's and women's preferences by analyzing how their votes differ in several topics in Switzerland. The authors found that women are 10 percentage points more likely to spend money on policies that protect the environment than men. Finally, recent concerns of women towards the environment have also increased over time. Using the "World Values Survey" (Inglehart et al., 2018A, 2018B), we find that women worldwide have increased their concern over environmental pollution and the degree of responsibility assigned to the government. Therefore, it is possible that female legislators are trying to protect the environment to advance the interests of the female population.

4 Data and Descriptive statistics

We use panel data for a sub-sample of high-income countries for the years 1990 and 1997-2015. Table 11 in the Appendix shows the list of all countries in our sample. We focus on the high-income countries as categorized by the World Bank. These countries account for 56.19% of total renewable energy production without hydropower (Ritchie, 2017). Adding Brazil, China, and India accounts for 91.26% of the total renewable energy production (Ritchie, 2017). Thus, we include these countries as a robustness check.

Our variable of interest is renewable electricity production without hydropower. The World Bank (WBI.b, 2020) defines this variable as the proportion of electricity generated by renewable plants to total electricity production. Renewable plants include geothermal, solar, tidal, wind, biomass power, and biofuel plants. We exclude hydropower following Verdolini et al. (2018) and Popp et al. (2011), as they argue that it is a mature source of renewable energy, in which most deployment has already occurred. Nevertheless, we add hydropower to the main specification(equation 3) as a robustness check.

The main independent variable is the proportion of women in parliament. The World Bank defines this variable as "the percentage of parliamentary seats in a single or lower chamber held by women" (WBI.a, 2020).[3] The proportion of women in national parliaments in the world in 1997, considering single or lower chambers, was 11.69%, in 2019, it increased to 24.64% (WBI.a, 2020). During that period, the proportion of women in the single or lower chamber increased by 83.25% in high-income countries. The evolution of seats held by females in parliament, for all countries, and for high-income countries is presented in Figure 3 and 4, respectively.

Despite gaining more seats over time, the total participation rate of women remains fairly low. Consuently, several countries have implemented gender quota laws to reduce this gap. In our sample, 13 countries passed a gender quota law (see Table 9 in the Appendix for further

[3]This variable considers presidential and parliamentary government systems.

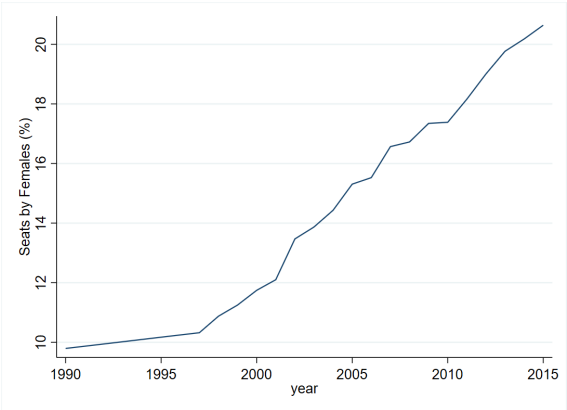


Figure 3: Percentage of seats held by females for all countries. Source: WBI.a (2020)

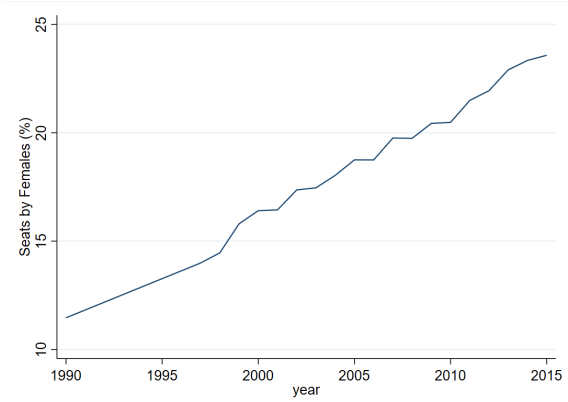
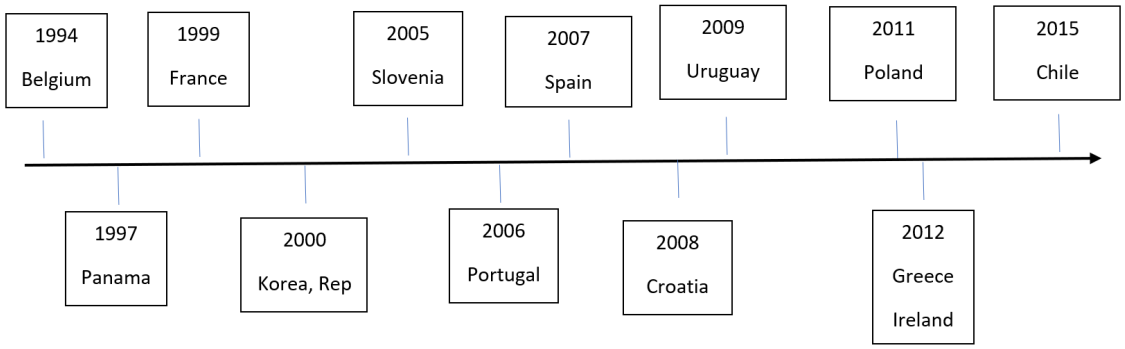


Figure 4: Percentage of seats held by females for High-income countries. Source: WBI.a (2020)

details). We use a dummy for when a quota law was passed in the lower or single house as an instrument (IDEA, 2020; ECLAC, 2020). We consider only the quotas that specify a percentage of seats for females[4]. In Figure 5, we present a timeline that shows when a quota law was adopted.

Figure 5: Quota Law timeline.



This figure shows the timeline when high-income countries adopted a quota law. Source: (IDEA, 2020; ECLAC, 2020).

Data for the "years since women's suffrage" is collected from historic newspapers (Historic, 2020), which refers to the years when women were allowed to vote nationally. This variable is

[4]Italy was ruled out because its quota law does not specify the number of seats for women, only that "male/females should have ual opportunities" (IDEA, 2020).

used as a second instrument. The instrument was constructed as follows. First, we obtained the year in which suffrage was expanded to women for each country in the sample (refer to Table 19 in the Appendix for more information). Second, we compute the difference between the years of the data (1990, 1997-2015) minus the year suffrage was expanded to women.

We also use the (logarithm of the) GDP *per capita* at constant 2010 dollars as another control (WB.c, 2020). In addition, we use Freedom House's Civil Liberties Index. This index ranges from 1 to 7, where 7 represents the lowest level of freedom, and 1, is the highest. Thus, an increase in the index reflects a decrease in civil liberties.

(House, 2020).

Table 1: Descriptive Statistics

	Mean	Standard Deviation	Min.	Max
Pct. renewable energy prod. (No hydropower)	5.54	7.78	0	65.44
Pct. renewable energy production	26.88	29.66	0	99.88
Quota law	0.16	0.37	0	1
Pct. women legislature	21.4	10.8	1.4	47.3
GDP *per capita*	33962.2	20086.8	4061.6	111968.4
Right-wing	0.49	0.5	0	1
Center	0.14	0.35	0	1
Left-wing	0.37	0.48	0	1
Civil liberties	1.32	0.54	1	4
Parliamentary	0.8	0.40	0	1
Years since women's suffrage	70.82	20.04	14	122

Furthermore, we add the political orientation (right-wing, left-wing, or centrist) of the party that wins the election (Cruz et al., 2016). The election-winning party is categorized as right-wing if the party is self-defined as conservative, Christian democratic, or right-wing.[5] A left-wing party is designated as such if it considers itself socialist, social-democratic, communist, or left-wing. Finally, a party is considered centrist if it is self-defined as such. Parties that do not conform to the previous categories are ruled out. We transform the categorical variables into dummies. Lastly, we add another specification on whether the system is parliamentary or presidential (CIA, 2020) (see Appendix Table 13 for more details). Specifically, we create a variable that uals one if the system is parliamentary (i.e., parliamentary republic, federal parliamentary democracy under a constitutional monarchy, federal parliamentary republic, parliamentary constitutional monarchy, parliamentary democracy, or parliamentary democracy under a constitutional monarchy).

Table 1 presents descriptive statistics of the data used in the regression analysis. On average, the percentage of renewable energy production without hydropower for the countries in our sample is 5.54%. However, there is a large discrepancy among countries, with one country having a maximum of 65% of renewable production. Considering renewable energy with hydropower, the average production increases to 27%. The percentage of females in the legislature is 20%. Even though female representation has increased gradually over time, as shown in Figure 4, it is still far from achieving gender parity.

5 Methodology

Our econometric specification is the following[6]:

$$y_{it} = \alpha + \rho W_{it} + \beta X_{it} + \delta_i + \gamma_t + \epsilon_{it} \tag{1}$$

[5]More precisely, Cruz et al. (2016) use "chief executive's party's."

[6]we use the Stata command from Schaffer (2020).

where y_{it} is the proportion of renewable energy sources in a country's overall electricity production i at time t without hydropower. The proportion of seats held by women in the national parliament of country i at time t is represented by the variable W_{it}. X_{it} is a set of time-variant variables linked to both the percentage of female legislators and the use of renewable energy: the logarithm of GDP *per capita* of country i at time t, the government of country i at time t is right-wing, centrist, or left-wing, and the civil rights index. Time invariant country fixed effects and time dummies for 1990 and 1997 to 2015 are represented by δ_i and γ_t, respectively. Finally, ϵ_{it} is the error term.

Identifying the impact of higher female participation in parliament on the level of renewable energy production is not straightforward. Are countries that favor more renewable energy likewise more likely to elect women to the legislature because they are inherently more progressive, or do women want more renewable energy? This is complicated to analyze without conducting an experiment. The optimal identification strategy would be to randomly select some countries to assign them a certain number of women in their parliaments and then analyze their differences in renewable production outcomes.

In particular, there could be some omitted-variable bias, such as, cultural or historical persistence. In order to try to mitigate this problem, we apply an IV- approach and add year and country fixed effects. Furthermore, we control for variables that simultaneously impact both the number of female legislators in the parliament and the production of renewable energy simultaneously (X_{it}). To achieve this objective, we employ two instruments: quota laws and years since women's suffrage.

The variable "countries with legislated candidate quotas in the lower or single house," is obtained from the IDEA (2020); ECLAC (2020) websites. The instrument is equal to one if the law requires that a certain number of seats be reserved for women's (Z_{it}). Table 9 in the Appendix describes the quota laws for each country.

Thus, the first stage of our estimation is:

$$W_{it} = \alpha^{'} + \phi Z_{it} + \beta^{'} X_{it} + \delta_i^{'} + \gamma_t^{'} + \eta_{it} \tag{2}$$

And the second stage:

$$y_{it} = \alpha + \rho \hat{W}_{it} + \beta X_{it} + \delta_i + \gamma_t + \epsilon_{it} \tag{3}$$

For the instrument to work, it must be relevant first. In this case, the gender quota law must have a positive and significant effect on the proportion of women in the parliament. Second, the instrument must comply with the exclusion restriction. This means that the instrument must be as good as randomly assigned and can only affect the percentage of renewable electricity output by the variable we want to instrument, that is, the proportion of females in parliament.

The exclusion restriction may not hold if countries that pursue diversity strongly enough to pass a quota law also care more about the environment. Nevertheless, quota laws are passed to increase diversity, which differs from progressiveness. More progressive countries want to increase the number of females in policy-making positions and increase the production of renewable energy. A quota law increases the former but not necessarily the latter. For example, Haiti passed a quota law in 2012, granting 30% of its seats to women (ECLAC, 2020). Nevertheless, their Freedom House's Civil Liberties Index score for the same year was 5, meaning that it was considered only partially free (House, 2020). Second, we only consider countries in which the law requires at least a percentage of their seats to be held by females. Third, women in legislative bodies have been underrepresented for decades, therefore, passing a quota law has, in principle, the sole effect of reducing gender inequality. The channel we are exploiting is the following: passing a quota law increases the number of females in parliament, who push for different policies than men.[7].

[7]It could be the case that a reverse causality and/or a measurement error problem arises. However, we do not believe this is the case. For the latter, the data is obtained from official and external sources. For the

We cluster the sample at the country level to allow residuals to have an unrestricted correlation within countries (Angrist & Pischke, 2008) and time. Our sample has 41 clusters that are categorized as high-income by the World Bank. However there are disparities between them. For example, Table 1 illustrates that Iceland and Norway have more than 65.4% of their energy produced by renewable sources (without considering hydropower), whereas the average of the entire sample is 5.5%. Finally, 11 out of 41 countries in the treatment have passed a quota law; hence, the number of clusters is less than 42 (Angrist & Pischke, 2008); they are not homogeneous; and we might have a small number of treated clusters. Roodman et al. (2019) recommend finding p-values via bootstrap if either of these conditions holds because they lead to over-rejection. We follow Cameron et al. (2008) and use a wild-bootstrap. We present bootstrap p-values in the main estimation results.[8]

We also employ "years since women's suffrage" (Grier & Maldonado, 2015; Hicks et al., 2016; Mavisakalyan & Tarverdi, 2019). Hicks et al. (2016) and Mavisakalyan and Tarverdi (2019) show that women's suffrage is correlated with having more women in parliament (a strong first stage); therefore we use this variable as an instrument to estimate equation (2) and (3). The presence of more equitable nations does not automatically imply a higher prevalence of progressive nations. While progressive countries are characterized by greater fairness, it should be noted that fairness alone does not guarantee progressiveness. This is particularly relevant when considering the historical context, as global approval of women's suffrage occurred, on average, in 1933. The mechanism exploited is as follows: an expansion in the right to vote for women implies that women can choose according to their beliefs, shape policy outcomes, and increase their participation. However, "years since women's suffrage" should have a highly diluted impact on current outcomes.

former, we cannot think of a reason why an increase in the production of renewable energy increases female participation in parliament.

[8]We use the boottest Stata command with 9999 draws (Roodman et al., 2019).

6 Results

Tables 2 and 3 present the first and second stage estimates of the main specification (equation 3). This study focuses on high-income countries defined by the World Bank, which account for approximately 56% of the total worldwide production of renewable energy (without hydropower) (Ritchie, 2017).

The OLS estimation results are presented in the first column of Table 3. The coefficient for the variable "proportion of women in parliament", including all controls, is 0.035 (0.136), which is not statistically significant. There could be some omitted variable bias that is negatively correlated with the variable of interest; therefore, we instrument this variable by using quota laws and years since women's suffrage.

Table 2: First Stage Estimation

	Pct. Of Women in parliament			
	(1)	(2)	(3)	(4)
Quota Law	2.696***	2.658***	2.704**	2.443**
	(1.003)	(1.03)	(1.059)	(1.113)
Log GDP *per capita*		0.933	1.172	0.885
		(3.444)	(3.489)	(3.77)
Right-wing			-0.268	-0.17
			(0.471)	(0.444)
Centrist			-0.757	-0.738
			(0.692)	(0.7)
Civil liberties				-1.525
				(0.648)
Country fixed effects	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y
N	704	704	704	704

This table shows the impact of adopting a quota law on the percentage of women in parliament. Standards errors are clustered at the country level, in parentheses. Significance levels: ***0.01 **0.05 *0.1.

The first stage is presented in Table 2, in which we use quota laws as an instrument for the proportion of women in parliament. Our preferred specification is the fourth column, which includes all the controls. In this specification, the introduction of a gender quota law increases the proportion of women in parliament by 2.4 percentage points. The coefficient is significant at 5%. We also find that the instrument used is robust to different specifications, as shown in Columns 1-4 of Table 2.

Table 4: IV Estimation of Renewable Energy

	Percentage of renewable energy production (no hydropower)				
	OLS	IV estimation			
	(1)	(2)	(3)	(4)	(5)
Pct. women parliament	0.0353	1.329***	1.462**	1.463**	1.644**
	(0.136)	(0.748)	(0.739)	(0.761)	(0.875)
	[0.815]	[0.0002]	[0.039]	[0.041]	[0.031]
Log GDP *per capita*	-6.27		-8.81	-8.949	-8.621*
	(5.76)		(6.516)	(6.764)	(7.518)
	[0.331]		[0.109]	[0.119]	[0.081]
Right-wing	-0.031			0.427	0.29
	(0.703)			(0.905)	(0.951)
	[0.964]			[0.535]	[0.682]
Centrist	-0.240			0.548	0.65
	(1.126)			(1.516)	(1.628)
	[0.837]			[0.708]	[0.641]
Civil liberties	0.03				2.868**
	(0.856)				(2.009)
	[0.971]				[0.025]
Country fixed effects	Y	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y	Y
N	704	704	704	704	704

Column 1 shows the OLS results of the effect of women in parliament on renewable energy production. Columns 2 through 5 present the IV results of the effect of women in parliament on renewable energy production. Standard errors are clustered at the country level in parentheses. Wild bootstrap p-values in square brackets. Significance levels: ***0.01 **0.05 *0.1.

According to the results of the second-stage estimation in Table 3, we find that a 1 percentage point increase in the proportion of women in parliament increases the percentage of renewable energy production by 1.64 percentage points as shown in Column 5, which is the preferred specification. The coefficient is significant at 5%, after controlling for the type of government, the degree of civil liberty, and the log of GDP *per capita* in 2010 constant dollars. Analyzing the magnitude of the effect, a 1 standard deviation change in the proportion of women in parliament generates a 2.2 standard deviation change in the proportion of renewable energy without hydropower.

The majority of the controls are not statistically significant. The coefficients for the type of party and civil liberties have an unexpected sign, especially, considering that an increase in the former happens when the Government moves further to the "left". Having a right-wing government or a centrist government has a positive (yet not significant) impact on the production of renewable energy in comparison to that of a left-wing government. 1 is the highest level of freedom as per the Civil Liberties Index. Thus, increasing a unit in the Civil Liberties Index (i.e., a decay in the Civil Liberties Index) implies a higher effect on renewable energy. Finally, the fact that the logarithm of GDP *per capita* is negative is also counter-intuitive. However, the fact that we focus on high-income countries may explain this result. For example, the level of renewable energy depends on large-scale projects that may require external funds. Furthermore, despite being counter-intuitive, our results are similar to those of Dong (2012), and Yin and Powers (2010).

We try different specifications by adding interactions, for example, (Parliamentary $*$ prop women parliament(and (Prop. women parliament $*$ Civil liberties). The results are presented in Appendix Table 14. The results from the reduced form estimation are presented in the Appendix Table 15.

The IV results and the first stage using "years since women's suffrage" as an instrument can be seen in Table 6 and Table 5, respectively. The first stage is robust and has a positive

sign. Our preferred specification is Column (4), which includes all the controls. In such specification, allowing women to vote a year earlier increases the proportion of women in the parliament by 0.56 percentage points. In the second stage, the coefficient is 0.74 after controlling for the type of government, the degree of civil liberties, and the log of GDP *per capita* in 2010 constant dollars. Thus, a one percentage point increase in the percentage of women in parliament increases the production of renewable energy without hydropower by 0.74 percentage points. The coefficient is significant at 1%. Therefore, using a completely different instrument yields a slightly lower but positive and significant result, which is consistent with our previous results.

Table 5: First Stage Estimation

	Pct. of women in parliament			
	(1)	(2)	(3)	(4)
years since	0.622***	0.582***	0.577***	0.564***
women's suffrage	(0.061)	(0.114)	(0.116)	(0.119)
Log GDP *per capita*		1.714	1.875	1.464
		(3.387)	(3.467)	(3.777)
Right-wing			-0.319	-0.199
			(0.473)	(0.438)
Centrist			-0.552	-0.554
			(0.578)	(0.594)
Civil liberties				-1.765
				(0.662)
Country fixed effects	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y
N	704	704	704	704

.

This table shows the effects of the number of years since women's suffrage was allowed on the percentage of women in parliament. Standards errors cluster at country level, in parentheses. Significance levels: ***0.01 **0.05 *0.1.

Table 6: First Stage of Years since women's suffrage on the Proportion of Women in parliament

	Percentage of renewable energy production (no hydropower)			
	(1)	(2)	(3)	(4)
Prop. women parliament	0.44	0.725***	0.725***	0.741***
	(0.094)	(0.278)	(0.291)	(0.298)
	[0.001]	[0.0]	[0.0]	[0.0]
Log GDP *per capita*		-7.545*	-7.566**	-7.299**
		(6.07)	(6.402)	(6.351)
		[0.060]	[0.035]	[0.05]
Right-wing			0.191	0.11
			(0.699)	(0.728)
			[0.891]	[0.956]
Centrist			0.141	0.15
			(1.339)	(1.378)
			[0.807]	[0.836]
Civil liberties				1.275
				(1.23)
				[0.354]
Country fixed effects	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y
N	704	704	704	704

The IV results of the effect of women in parliament on renewable energy production are presented. Standards errors cluster at country level, in parentheses. Wild bootstrap p-values, in square brackets. Significance levels: ***0.01 **0.05 *0.1.

7 Robustness Checks

We conduct a set of placebo tests by changing the quota law adoption by 2 and 4 years (Angrist & Pischke, 2008). We also randomly assign a new quota law to the treated countries.[9] The "anticipatory" and "random" effects should have no impact on the production of renewable energy. Lastly, we do our preferred specification but drop the year 1990. The results ate presented in Table 7.

The first 3 placebo tests perform as expected. There is no significant effect of the proportion of women in parliament on the production of renewable energy if I use the "fake" gender quota laws as an instrument. This validates our causal interpretation.

Given the lack of continuity in the data, in which we have observations for the year 1990 and from 1997 to 2015, we drop 1990 as a robustness check. Column 4 of Table 7 shows our preferred specification, with all the controls, excluding 1990. The coefficient is higher and significant, so we can conclude that the causal effect is not driven by 1990.

In addition, we drop each treated country at a time and run the main specification (3) at a 95% confidence level. The results are presented in Table 17 in the Appendix. None of the countries drive the results alone; the point estimations are close to each other and are always significant at 5% or 10%.

Furthermore, we add three more countries, Brazil, China, and India, which together with the original sample, account for 91.26% of the global renewable electricity production without hydropower (Ritchie, 2017)). The coefficient of the percentage of women in parliament decreases slightly; from 1.64 to 1.46 and is significant at the 5% level. Lastly, we add nine more countries; Brazil, China, India, Indonesia, Mexico, the Philippines, South Africa, Thailand, and Turkey to the original sample. These countries account for 96.11% of the renewable energy production without hydropower worldwide (Ritchie, 2017). The coefficient on the percentage of women in parliament increases from 1.64 to 2.17 and is still significant

[9] See Table 16 in the Appendix to check the exact quota law dates.

Table 7: Robustness checks

Percentage of renewable energy production (no hydropower)

	Quota$_{(2yrs\ lag)}$ (1)	Quota$_{(4yrs\ lag)}$ (2)	Quota$_{Random}$ (3)	Quota$_{(wo/1990)}$ (4)
Prop. women parliament	2.951	4.105	0.743	1.883*
	(2.296)	(4.756)	(0.632)	(1.088)
	[0.130]	[0.192]	[0.157]	[0.063]
Log GDP *per capita*	-10.536	-12.225	-7.303	-13.736
	(11.585)	(16.572)	(5.954)	(10.08)
	[0.116]	[0.162]	[0.436]	[0.109]
Right-wing	0.550	0.781	0.11	0.601
	(1.435)	(1.978)	(0.760)	(1.022)
	[0.618]	[0.606]	[0.815]	[0.462]
Centrist	1.374	2.013	0.152	1.224
	(2.513)	(3.7)	(1.341)	(1.683)
	[0.409]	[0.353]	[0.923]	[0.446]
Civil liberties	5.175*	7.212	1.28	3.343**
	(4.846)	(9.2)	(1.357)	(2.975)
	[0.061]	[0.145]	[0.126]	[0.049]
Country fixed effects	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y
N	704	704	704	674

The IV results on the effect of women in parliament on the percentage of renewable energy are presented. Column 1 uses a fake quota as an instrument; it takes the value ual one, two years before the actual implementation. Column 2 uses a fake quota as an instrument; it takes the value ual one, four years before the actual implementation. Column 3 uses a fake random quota law as an instrument. Column 4 drops the data from the year 1990. Standards errors cluster at country level, in parentheses. Wild bootstrap p-values, in square brackets. Significance levels: ***0.01 **0.05 *0.1.

at 5%. The results can be seen in Table 18, Columns 1 and 2, respectively.

Finally, we estimate equation (3) using the proportion of renewable energy production with hydropower as the dependent variable. The coefficient of the proportion of women in parliament is 1.1, after controlling for the type of government, the degree of civil liberty, and the log of GDP *per capita* in 2010 constant dollars. The effect is smaller but significant at

10%, which is consistent with the idea that hydropower is considered a mature energy source where most of the deployment has already occurred (Verdolini et al., 2018; Popp et al., 2011). The results are presented in the Appendix in Table 12.

We also perform the Sargan-Hansen test of overidentification, and we are not able to reject the null hypothesis (the p-value is equal to 0.334). Therefore, at least one of the instruments is exogenous and does not correlate with the error term.

This section ratifies the relevance of the instrument to the main causal findings. The introduction of a quota law increases the number of women in parliament, which potentially, through an increase in the number of policies and laws adopted (as discussed in Section 3), is one mechanism for increasing the production of renewable energy. However, these results can be extrapolated only to high-income countries. Middle and low-income countries have several dissimilarities. Although having more women in policy-making positions has a positive impact, it does not necessarily translate into an increase in renewable energy production.

8 Conclusion

More women in policy-making positions increase the production of renewable energy without hydropower, after controlling for several factors. These results add to the literature on cross-country analyses that link women in parliament to several outcomes. By using an IV panel with fixed effects and considering 41 high-income countries for the years 1990, 1997-2015, we reinforce the argument that women in policy-making positions support the environment by increasing renewable energy production.

By using two different instruments, passing a quota law and years since women's suffrage to control for possible omitted variable bias, we found qualitatively similar results. Women in parliament increase the production of renewable energy production between 0.74 and 1.64 percentage points, after controlling for the log of GDP, type of government, and Civil Liberties

Index.

It has been documented that female legislators support different policies compared to male legislators. Thus, enhancing government performance necessitates a focus on increasing the participation of women, as well as promoting diversity in a broader sense. Furthermore, this study shows that having more women in parliament has a positive and significant effect on the production of renewable energy, perhaps because of an increase in the number of environmental protection-related legislations and laws proposed by women. Consequently, having more female representatives has an important effect on the decarbonization of the economy, which is a positive externality for the rest of the world. Introducing or strengthening quota legislation is a strategy to enhance representation.

Due to the inherent differences between middle and low-income countries and high-income countries, these results cannot be extrapolated to other types of countries. Therefore, although having more women in positions of influence would undoubtedly boost diversity, it would not always result in the production of more renewable energy.

A potential avenue for further investigation would involve examining diversity across countries and delving into the reasons behind the specific developmental trajectories observed in high-income countries. This would explore the presence of alternative mechanisms and how they vary across middle-income and low-income countries. Additionally, it would investigate why middle-income nations were at the forefront of the deployment of renewable energy before things slowed down.

9 Competing interest

Declarations of interest: none.

10 Appendix

Table 8: OLS Results for the Effect of Female Participation in the Production of Renewable Energy - All Countries

	Pct. Renewable energy production (no hydropower)			
	(1)	(2)	(3)	(4)
Prop. women parliament	0.631	0.691	0.698	0.702
	(0.416)	(0.429)	(0.438)	(0.437)
GDP *per capita*		0.0003	0.0003	0.0003
		(0.0001)	(0.0001)	(0.0001)
Right-wing			0.66	0.664
			(0.782)	(0.78)
Centrist			0.231	0.233
			(0.951)	(0.958)
Civil liberties				0.197
				(0.564)
Country fixed effects	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y
N	1524	1524	1524	1524

The OLS results of the effect of females in parliament on the production of renewable energy are presented. Standards errors cluster at country level, in parentheses. Significance levels: ***0.01 **0.05 *0.1.

Summary of the quota laws.

Table 9: Quota Law Description

Country	Year	Description
Belgium	1994	Political parties should not have more than 2/3 candidates of the same gender in their lists - first gender quota
Chile	2015	Neither the male candidates nor the female candidates may exceed 60% - Constitutional reform
Croatia	2008	If a gender (male or female) has less than 40% of representatives in the political arena, it is considered "under-represented" - Gender Equality Law
France	1999	Gender parity was obtained - Constitutional amendment
Greece	2012	One-third of parties' candidate list must have candidates of each gender - Presidential Decree 26/2012
Ireland	2012	30% of the candidates have to be women, and 30% have to be men - Electoral Act amended
The Republic of Korea	2000	Women candidates in political parties must have at least 30% of representation in their lists - Political party law reform
Panama	1996	The law requires that at least 30% of seats are reserved for women - Law 22, Art.182-A
Poland	2011	At least 35% of the candidates have to be women, and at least 35% have to be men - Election Code
Portugal	2006	Each gender has to have a minimum representation of 33% - Equality Law 3/2006
Slovenia	2005	A gender quota of 20% was introduced before the 2006 Election - Local Elections Act 2005 - art. 70
Spain	2007	Each gender has to have a minimum representation of 40% in the parties' candidate lists - Organic Law 3/2007
Uruguay	2009	If the first candidate in the party list is a man, then the second candidate has to be a women, and vice-versa

Sources: International Institute for Democracy and Electoral Assistance (IDEA, 2020) and/or Gender Equality Ob and the Caribbean (ECLAC, 2020).

Summary of the cross-country analysis of the effect of women in power positions on several outcomes.

Table 10: Summary of Cross-country and Gender Analysis

Authors	Outcome variable	Years	Countries	Paper
Shea and Christian	Humanitarian military intervention	1946-2003	59	The Impact of Women Legislators on Humanitarian Military Interventions
Ergas and York	CO_2 emission *per capita*	2004	103	Women's Status and Carbon Dioxide Emissions:A quantitative Cross-national Analysis
Pearl-Martinez	Protected land areas	2004	90	Women at the Forefront of the Clean Energy Future
Norgaard and York	Environmental treaty ratification	1999	130	Gender uality and State Environmentalism
Clayton and Zetterberg	Government spending	1995-2012	139	Quota Shocks: Electoral Gender Quotas and Government Spending Priorities Worldwide
Weeks	Government spending on family policies	1980-2011	22	Quotas Matter: The Impact of gender Quota Laws on Work-Family Policies
Swamy, Knack Lee, and Azfar	Corruption level and bribe acceptance	1981, 1990	93	Gender and corruption
Dollar, Fisman and Gatti	Corruption level	1985, 1990 and 1995	100	Are Women Really the "Fairer" Sex? Corruption and Women in Government
McElhaney and Mobasseri	Environmental, governance and social	2012	1500 firms	Women Create A Sustainable Future
Mavisakalyan and Tarverdi	Environmental policies and CO_2 emissions	2005 - 2010	91	Gender and climate change: Do female parliamentarians make difference?

Table 11: Countries in My Sample

Australia	Japan
Austria	Korea Republic
The Bahamas	Latvia
Barbados	Lithuania
Belgium	Luxembourg
Canada	Malta
Chile	Netherlands
Croatia	New Zealand
Cyprus	Norway
Czech Republic	Panama
Denmark	Poland
Estonia	Portugal
Finland	Slovakia
France	Slovenia
Germany	Spain
Greece	Sweden
Hungary	Trinidad and Tobago
Iceland	United Kingdom
Ireland	United States
Israel	Uruguay
Italy	

The Bahamas and Barbados were added to the database with no hydropower. In the database with hydropower, they have production ual to zero, however, in the database with no hydropower they appear as NA. Thus, we add their production as ual to zero in the database with no hydropower.

In the following table, we present the point estimation results using the percentage of renewable energy with hydropower as a dependent variable.

Table 12: IV Estimation of Renewable Energy with Hydropower

	Prop. Renewable energy production with hydropower			
	(1)	(2)	(3)	(4)
Prop. women parliament	0.716***	0.977	1.04	1.096*
	(0.839)	(0.642)	(0.632)	(0.711)
	[0.0]	[0.119]	[0.116]	[0.072]
Log GDP *per capita*		-17.171	-17.3	-17.198
		(4.764)	(4.781)	(4.857)
		[0.638]	[0.655]	[0.959]
Right-wing			1.858	1.815
			(0.974)	(0.989)
			[0.166]	[0.225]
Centrist			0.93	0.961
			(1.625)	(1.635)
			[0.758]	[0.659]
Civil liberties				0.886*
				(1.890)
				[0.053]
Country fixed effects	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y
N	704	704	704	704

The IV results of the effect of women in parliament on renewable energy production with hydropower are presented. Standards errors cluster at country level, in parentheses. Wild bootstrap p-values, in square brackets. Significance levels: ***0.01 **0.05 *0.1.

We also test whether having more women in the legislature has a more pronounced effect on parliamentary rather than presidential systems (see Table 13 for more details). Legislators under a parliamentary system may participate more actively and decisively than those under a presidential system. We present the point estimates in Table 14, column (1). Specifically, we create a variable that uals one if the government is parliamentary (i.e., parliamentary republic, federal parliamentary democracy under a constitutional monarchy, federal parliamentary republic, parliamentary constitutional monarchy, parliamentary democracy, parliamentary democracy under a constitutional monarchy (CIA, 2020)). Then, we create an interaction term ("*Parliamentary* $*$ *Prop. women parliament*") that considers the proportion of seats represented by women and parliamentary government. The point estimate for such interaction is negative and not significant, so the effect of being in a parliamentary system is inconclusive.

To further understand mechanisms, we interact the Proportion of women in parliament with the Civil Liberties Index. The estimation results are presented in Table 14. This shows how having more females in the legislature varies according to the Civil Liberties Index. Given how this variable is constructed, a decrease in the Civil Liberties Index indicates an improvement. The coefficient is negative and significant at 5%. Thus, having more women in the parliament has a more pronounced effect in countries with a lower index of civil liberties, i.e., a higher level of civil liberties.

Table 13: Government type

Government type	Countries
Constitutional federal republic	United States
Constitutional monarchy	Luxembourg
Federal parliamentary democracy under a constitutional monarchy	Australia Belgium Canada
Federal parliamentary republic	Austria Germany
Parliamentary constitutional monarchy	Denmark - Japan Netherlands - Norway Spain - Sweden - UK
Parliamentary democracy	Israel
Parliamentary democracy under a constitutional monarchy	The Bahamas - Barbados New Zealand
Presidential republic	Chile - Cyprus - Republic of Korea Panama - Uruguay
Semi - presidential republic	France Lithuania - Portugal
Parliamentary republic	Croatia - Czech Republic - Estonia Finland - Greece - Hungary Iceland - Ireland - Italy Latvia - Malta - Poland Slovakia - Slovenia - Trinidad and Tobago

This table shows the type of government each country has, as defined by the CIA (2020).

Table 14: IV Estimation of Renewable Energy production

	Pct. renewable energy production (no hydropower)	
	(1)	(2)
Prop. women parliament	1.89*	0.968**
	(0.828)	(0.538)
	[0.053]	[0.038]
	-0.739	
	(0.504)	
Parliamentary*prop. women Parliament	[0.17]	
Log GDP *per capita*	-5.91	-2.574
	(6.842)	(4.654)
	[0.383]	[0.637]
Right-wing	0.423	0.158
	(0.812)	(0.708)
	[0.581]	[0.823]
Centrist	0.522	-0.637
	(1.40)	(1.055)
	[0.766]	[0.49]
Civil liberties	2.2	7.69**
	(1.865)	(3.784)
	[0.176]	[0.027]
(Prop. women parliament* Civil liberties)		-0.55**
		(0.248)
		[0.025]
Country fixed effects	Y	Y
Year fixed effects	Y	Y
N	704	704

The IV results of the effect of women in parliament on renewable energy production are presented. The type of government is included as an extra control in column (1). "*Parliamentary* $*$ *prop.womenparliament*" uals one if the government is parliamentary, zero if it's non-parliamentary, e.g., a presidential republic. Column (2) controls for interaction between the proportion of women in parliament and the Civil Liberties Index. Standards errors cluster at country level, in parentheses. Wild bootstrap p-values, in square brackets. Significance levels: ***0.01 **0.05 *0.1.

In Table 15 we present the results from the reduced form estimation, as specified in equation (4):

$$y_{it} = \dot{\alpha} + \dot{\delta}_i + \dot{\gamma}_t + \dot{\beta} X_{it} + \dot{\phi} Z_{it} + \dot{\epsilon}_{it} \tag{4}$$

The reduced form estimation indicates that the quota law has a positive and significant effect on the production of renewable energy, which is consistent with our previous analysis. This provides further evidence that the instrument is valid. Nevertheless, we are not interested in the effect the quota law has on the production of renewable energy *per se*. Instead, we are interested in how passing a quota law increases the number of females in the legislature and how that increases the production of and investment in renewable energy.

Table 15: Reduced Form Estimation

	Prop. Renewable energy production (no hydropower)			
	(1)	(2)	(3)	(4)
Quota Law	3.583*	3.887**	3.955**	4.017**
	(2.021)	(1.880)	(1.883)	(1.866)
Log GDP *per capita*		-7.446	-7.235	-7.167
		(4.930)	(5.129)	(5.115)
Right-wing			0.034	0.011
			(0.635)	(0.657)
Centrist			-0.559	-0.563
			(1.006)	(1.02)
Civil liberties				0.361
				(0.838)
Country fixed effects	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y
N	704	704	704	704

The OLS results of the effects of passing a quota law on the production of renewable energy are presented. Standards errors cluster at country level, in parentheses. Significance levels: ***0.01 **0.05 *0.1.

This table shows the random draw that we treat as the new quotas laws. These new fake quota laws are used as instruments to test whether this random effect has any impact.

Table 16: Random quota law

Country	Quota Law
Belgium	1998
Chile	1995
Croatia	2015
France	2013
Greece	2012
Ireland	1998
Rep. of Korea	1993
Panama	2002
Poland	2015
Portugal	2004
Slovenia	2014
Spain	1997
Uruguay	2000

Source: own creation.

Table 17: IV Estimation of Renewable Energy production: Dropping each country at a time

	Prop. of renewable energy production (no hydropower)
Main specification	1.644**
	[0.031]
Belgium	1.746**
	[0.038]
Croatia	1.665**
	[0.018]
France	1.555**
	[0.024]
Greece	1.744*
	[0.057]
Ireland	1.287*
	[0.084]
Rep. of Korea	1.888**
	[0.03]
Panama	1.604**
	[0.026]
Poland	1.662**
	[0.038]
Portugal	1.563*
	[0.08]
Slovenia	2.114**
	[0.035]
Spain	1.476*
	[0.075]
Uruguay	1.203*
	[0.094]
Country fixed effects	Y
Year fixed effects	Y

The IV results of the effect of women in parliament on renewable energy production without hydropower are presented. In each line, the respective country is dropped. Significance level is set at 95%. Wild bootstrap p-values, in square brackets. Significance levels: ***0.01 **0.05 *0.1.

Table 18: IV Estimation of Renewable Energy Production without Hydropower - Extended Sample

Prop. of renewable energy production (no hydropower)		
	(1)	(2)
Prop. women parliament	1.459**	2.171**
	(0.768)	(1.382)
	[0.025]	[0.041]
Log GDP *per capita*	-2.301**	1.332*
	(5.573)	(9.127)
	[0.05]	[0.077]
Right-wing	0.096	0.826
	(0.801)	(1.262)
	[0.89]	[0.506]
Centrist	0.096	0.04
	(1.473)	(1.876)
	[0.93]	[0.911]
Civil liberties	2.052	3.182
	(1.486)	(2.715)
	[0.111]	[0.124]
Country fixed effects	Y	Y
Year fixed effects	Y	Y
N	763	831

The IV results of the effect of women in parliament on renewable energy production without hydropower are presented. In column 1, I added three more countries: Brazil, China, and India, which along with the original sample accounts for 91.26% of all the renewable energy production done worldwide. In column 2, also include Brazil, China, India, Indonesia, Mexico, the Philippines, South Africa, Thailand, and Turkey. This extended sample accounts for 96.11% of all the renewable energy production done worldwide. Standard errors cluster at country level, in parentheses. Wild bootstrap p-values, in square brackets. Significance levels: ***0.01 **0.05 *0.1.

Table 19 shows the year when suffrage was extended to women.

Table 19: Women's Suffrage in My Sample

Australia	1962	Japan	1946
Austria	1918	Republic of Korea	1948
Bahamas, The	1962	Latvia	1917
Barbados	1950	Lithuania	1917
Belgium	1948	Luxembourg	1919
Canada	1960	Malta	1947
Chile	1949	Netherlands	1919
Croatia	1945	New Zealand	1893
Cyprus	1960	Norway	1913
Czech Republic	1920	Panama	1946
Denmark	1915	Poland	1918
Estonia	1917	Portugal	1976
Finland	1906	Slovakia	1920
France	1945	Slovenia	1945
Germany	1918	Spain	1931
Greece	1952	Sweden	1919
Hungary	1918	Trinidad and Tobago	1946
Iceland	1915	United Kingdom	1928
Ireland	1922	United States	1920
Israel	1948	Uruguay	1932
Italy	1945		

Source: Historic (2020)

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