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Lin, X.-L., & Yin, H.-T. (2023). The Impact of Gender Equality on Green Innovation. *Energy RESEARCH LETTERS*, *4*(3). https://doi.org/10.46557/001c.36536

Peer-reviewed research

The Impact of Gender Equality on Green Innovation

Xi-Li Lin[1], Hua-Tang Yin[1a]

[1] School of Economics and Finance, Xi'an Jiaotong University, China

Keywords: Gender Equality, Green Innovation, Violence, JEL: Q55 J16

https://doi.org/10.46557/001c.36536

Energy RESEARCH LETTERS

Vol. 4, Issue 3, 2023

Employing a panel of 166 economies covering 1996 – 2018, we investigate the impact of gender equality on green innovation. Our findings indicate that an improvement in gender equality improves green innovation performance. This result is supported by a series of robustness tests. Additionally, we also find that this positive effect tends to be higher in economies with violent conflicts.

I. Introduction

In recent decades, harmful disasters owing to extreme high-frequency weather have caused extensive concern for how to balance economic development and climate change alleviation (Antal & Van Den Bergh, 2014; Bowen et al., 2011). Green innovation plays a crucial role in doing both (Cooke, 2013; Kunapatarawong & Martínez-Ros, 2016). The impact of green innovation on environmental-friendly development has been explored and confirmed by previous studies, from corporate decisions to the macro-economic course (Schiederig et al., 2012; Singh et al., 2020). Zheng et al. (2021) summarize comprehensively previous documents involving the driving factors of green activities, in which cultural and institutional foundation (Chen et al., 2018; Qi et al., 2021) are emphasized as an essential determinant of green innovation activities.[1] Gender equality, however, as an aspect of the cultural environment or institutional arrangement, may have the potential to significantly influence green innovation performance of an economy through its considerable impact on the labor market (Kylä-Laaso et al., 2021; Marija Sikirić, 2021; Nguyen, 2021), educational attainment (Campbell, 2021; Doğan & Kirikkaleli, 2021; Iranzo-Cabrera & Gozálvez Pérez, 2021) and human capital (Girón & Kazemikhasragh, 2021; Greer & Carden, 2021). While there is very little study focusing on the role of gender equality in green innovation activities, we look to fill this gap by an empirical investigation.

Since the prominent work by Galor and Weil (1996), gender equality, as an important aspect of socio-economic operation, has generated numerous studies regarding its economic consequences. Cuberes and Teignier (2013) conduct a splendid review of previous literature with respect to the relationship between gender equality and economic development. Further empirical research on the aggregate effect of the gender gap (and its moderator) are conducted by Cuberes and Teignier (2016) and Doepke and Tertilt (2019). Drawing lessons from their research, we find that there are some potential mechanisms through which gender equality may affect green innovation performance significantly. Lagerlof (2003) argues that a "gender-equal" equilibrium results in a shift from quality to quantity in family spending on children., facilitating the accumulation of human capital. Esteve-Volart (2004) and Wiswall and Zafar (2017) also emphasize that narrowing the gender gap helps alleviate distortion of talent. Moreover, Bloom and Williamson (1998) and Azmat and Petrongolo (2014) find that an improvement in gender equality not only reduces the number of children born to a family (and hence public saving rearing cost) but also increases the available labor force. Subsequent studies (such as Cuberes and Teignier (2012), Cuberes and Teignier (2016), Thrane (2008), Brixiová et al. (2020), etc.) also reiterate the importance of the role that gender equality plays in enhancing human capital intensity and expanding labor supply. A higher level of human capital as a result of gender equality increases innovation capacity (Dakhli & De Clercq, 2004; Danquah & Amankwah-Amoah, 2017) and environmental awareness (Constant & Davin, 2018; Zivin & Neidell, 2013) of an economy, which may promote green innovation performance (Zhou et al., 2021). The more sufficient labor supply resulting from a reduction in sexual discrimination also favors the diffusion and upgrade process of environmental-related technologies (Dawid et al., 2013; Greenhill et al., 2009), thus facilitating green innovation activities (Hall & Helmers, 2013). Hence, an improvement in gender equality may have the potential to boost green innovation.

a **Corresponding author:**
kevin_yhtang@foxmail.com

1 Readers can also refer to Takalo et al. (2021) for a more systematic literature review of green innovation.

In this study, we first use a panel of 166 economies covering 1996 – 2018 and employ a fixed effect model to investigate the influence running from gender equality to green innovation. A series of tests are then performed to verify the robustness of our baseline conclusion. We find that gender equality does have a significantly positive effect on green innovation. Additionally, our heterogeneity analysis shows that this impact is found to be more profound in those economies associated with higher levels of violent conflicts.

The remainder of this paper is organized as follows. Section II presents the model specification and data. Section III provides the results. Section IV concludes the paper.

II. Model specification and Data

We adopt a two-way fixed-effect model to investigate the impact of gender equality on green innovation. The model specification is as follows:

$$GI_{i,t} = \alpha_0 + \alpha_1 Gen\_EQ_{i,t} + \gamma Z_{i,t} + \mu_i + v_t + \varepsilon_{i,t} \quad (1)$$

where GI denotes the number of environmental-related patents that measures green innovation performance, Gen_EQ represents the degree of gender equality, Z regards a vector of control variables [including *GDP* (economic development), *GOV_GE* (government efficiency), *POP* (population size), *Common* (common-good supply), *Judicial* (judicial quality) and *Democracy* (the level of democracy)],[2] u_i and v_t signify the country- and time-fixed effect, and $\varepsilon_{i,t}$ refers to the error term. All the data for the above-selected variables are obtained from World Bank Open Data, OECD Statistics and V-Dem dataset.

III. Results

A. Baseline result

Column (1) of Table 1 presents the baseline model estimated by the fixed-effect approach. When adding all covariates, *Gen_EQ* is shown to be significantly positive at the level of 5%. This reveals that an improvement in gender equality promotes green innovation performance of an economy.

B. Robustness checks

B.I. Alternative core indictors

To confirm whether our baseline result is sensitive to specific indicators, we replace *Gen_EQ* with an inverse index of gender equality (*Gen_IEQ*, released by Quality of Government Dataset) and re-estimate the baseline model. Column (2) gives the result, in which *Gen_IEQ* enters negatively at the level of 1%, supporting our baseline result. Similarly, columns (3)–(4) keep the key explanatory variable unchanged but replace the green innovation indicator (GI) with *GI_EM* (environment-monitoring patent) and *GI_CCM* (climate-change mitigation patent) respectively, which also provide supporting evidence for the baseline result.

B.II. Fungible model specification

Since the generation of *GI* can be regarded as a series of events that randomly occur over time, a Poisson, or Negative Binomial (NB) model may be more suited to capturing its variation. We hence perform the estimation adopting these two specifications respectively. Columns (5)–(6) present the result. The coefficient of *Gen_EQ* remains significantly positive regardless of whether the Poisson or NB model is adopted, which again confirms the baseline result.

C. Heterogeneity

To explore whether the positive impact of gender quality on green innovation varies across the level of violence, we interact *Gen_EQ* and *Violence* (a measure of violent conflicts) and re-estimate our model. It is found that the cross-product term is positively significant, showing that the positive impact generated by gender-equality enhancement is higher in those economies with more violent conflicts.

IV. Conclusion

This paper fills the research gap about the relationship between gender equality and green innovation. Our findings indicate that an enhancement in gender equality benefits green innovation activities of an economy, and this positive impact is more profound in economies with more violent conflicts.

According to our findings, policy decision-makers may need to consider improving gender equality that facilitates green innovation to realize their sustainable development targets. For economies with relatively lower levels of gender inequality, policy decision-makers could prescribe proper punitive measures for discriminatory behaviors in the job market and carry out schemes with more fair education resource allocation to correct the distortion of the element usage that do harm to sustainable development by weakening green innovation activities. In economies with severe gender inequality, the culture of discrimination among different sexes has widely permeated various aspects of their existing institutions and systems. Authorities of economies with high levels of gender inequality should be more prudent about measures to rectify social instability by proposing radical policy reforms, especially in developing countries where systems for controlling violence are

2 The consistency of the estimator with respect to the causality impact running from gender equality to green innovation could be interrupted by some confounding factors. Following insights from the work of Wang et al. (2019) and Wen et al. (2021), we incorporate this suite of control variables (*GDP*, *GOV_GE*, *POP*, *Common*, *Judicial* and *Democracy*) to account for the bias generated from economic condition, institutional quality and population size.

Table 1. The empirical results of the impact of gender equality on green innovation

	(1) GI	(2) GI	(3) GI_EM	(4) GI_CCM	(5) GI	(6) GI	(7) GI
Gen_EQ	0.2214**		0.1690*	0.2370**	0.1184***	0.3438***	-0.0182
	(2.40)		(1.69)	(2.54)	(11.73)	(9.28)	(-0.12)
Gen_IEQ		-2.6474***					
		(-5.24)					
GDP	-0.1583	-0.1776	-0.1795	-0.2015	-0.1864***	0.1428**	-0.1469
	(-1.09)	(-1.24)	(-1.36)	(-1.32)	(-19.72)	(2.52)	(-1.01)
GOV_GE	0.2910***	0.1219	0.2236**	0.2600**	0.3361***	0.4782***	0.2914***
	(2.61)	(1.35)	(2.36)	(2.28)	(44.04)	(10.16)	(2.67)
POP	-0.0152	-0.3192	0.1084	-0.3735	2.4216***	0.1247***	0.0254
	(-0.04)	(-1.12)	(0.40)	(-1.09)	(49.31)	(4.05)	(0.07)
Common	-0.0421	-0.0779*	0.0043	-0.0678	0.0596***	-0.1151***	-0.0338
	(-0.89)	(-1.73)	(0.10)	(-1.51)	(12.35)	(-3.59)	(-0.71)
Judicial	-0.0205	-0.0591	-0.0077	-0.0284	0.0407***	-0.0421	-0.0231
	(-0.37)	(-1.23)	(-0.15)	(-0.51)	(6.30)	(-1.48)	(-0.42)
Democracy	-0.5401	-0.2968	-0.5062*	-0.5678*	-1.1659***	0.3254**	-0.6148*
	(-1.65)	(-1.02)	(-1.68)	(-1.80)	(-49.73)	(2.16)	(-1.73)
*Gen_EQ*Violence*							0.3780*
							(1.95)
Violence							-0.2698
							(-1.12)
N	3246	1473	3246	3246	3145	3145	3246
R^2	0.2961	0.2590	0.1531	0.3178			0.2996

Notes: This table shows the regression results of the impact of gender equality on green innovation. t-statistics are in parentheses; * p<0.1, ** p<0.05, *** p<0.01.

relatively weak. Although our findings suggest that an improvement in gender equality yields more in promoting green innovation, it would be useful to keep in mind that an 'impertinent' reform may bring about huge social costs that offset the anticipated benefits of green activities. This is because a sudden break in cultural factors and accepted norms could cut off numerous social linkages. Thus, the shifting path to a gender-equality development pattern should be carefully designed. For instance, instead of enacting harsh punitive measures regarding sexual discrimination, a recommended course of action would be encouraging equal treatment in economic activities [for example, by offering a tax credit for employing women] that gradually transforms the long-standing status quo of gender inequality.

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