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Green financing of eco-innovations: is the gender inclusivity taken care of?

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ABSTRACT

The OECD countries are in pursuit of the betterment of environmental quality based on their capability of Eco-innovation. This progression might pave their ways in attaining the Sustainable Developmental Goals (SDGs). Developing a green financing channel for funding is necessary for the sustenance of these projects. However, the potential impact of this project financing mechanism is conditional on the social balance in the economic system. Gender inequality being a major social issue in the OECD countries, it might pose a predicament in attaining the full potential of the green financing of eco-innovations. It is anticipated that the eco-innovation endeavors in the OECD countries are not gender-inclusive, and hence, gender inequality might limit the cognitive aptitude of these endeavors. The present study intends to assess the moderating role of gender inequality on the impact of green financing of eco-innovations for the OECD countries. Using the dynamic elasticity modeling approach, the study finds that the presence of gender inequality dampens the potential of green financing mechanisms to boost eco-innovations. The social imbalance caused by gender inequality also weakens the impacts of the structural and institutional environment to foster innovations. Based on the findings of the study, an SDG-oriented policy framework has been suggested.

1. Introduction

The recent COP26 Summit in Glasgow has focused at the issue of rising climatic shift. Nations around the world need to transform their prevailing economic growth trajectory for tackling this issue. The possible policy interventions in this regard have reinstated the classic *growth-development tradeoff*. A revolution in the traditional growth driver is necessary for addressing this tradeoff while assuring environmental sustainability. In this pursuit, the nations are newly recognizing their innovation capabilities, and this retrospection is gradually changing the facade of innovation.

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According to the recent Sustainable Development Goals (SDGs) progress report 2020, a transitional trajectory to sustainable development can be realized through an overhaul of the existing production processes, by means of various facets of the innovation. This revamped role of innovation might be crucial for the countries with pro-growth objective. Hailing to this objective compels the policymakers to follow the growth trajectory for building economic prosperity, even to the detriment of environmental quality. Therefore, structural transition of these economies toward the attainment of sustainable development path will entail embracing the eco-innovation solutions. This might encompass switching to renewable sources of energy by renouncing fossil fuel usage, and improving the energy efficiency of the existing production processes. The importance of this issue can be seen in the *Sustainable Development Report 2021*, which has shown the challenge the world is facing to attain the objectives of SDG 13, i.e., climate action (Sustainable Development Solutions Network (SDSN), 2021). Out of all the countries, the Organization for Economic Co-operation and Development (OECD) countries need a special mention, as all the OECD member countries have failed to make any progress in attaining the objectives of SDG 13. The recent environmental quality assessment report published by OECD (2021a) also stresses this fact. The gradual rise in fossil fuel usage in these countries has emasculated the effort of alleviating the problem of climate change. Therefore, the policymakers in these nations need to make policy interventions to curb the usage of fossil fuels and encourage the generation of renewable sources of energy. This process might be made possible by the eco-innovation initiatives. Now, the sustenance of these initiatives requires funding support from the investors. However, financing the eco-innovations in the form of climatic finances or green finances is another pressing issue around the globe. The financial aids toward the development of environmental technologies are below the level prescribed in the Paris Agreement (IISD, 2020). One of the major reasons behind this is the financial risk associated with the eco-innovation projects. Mitigation of this risk needs the involvement of public funding. The OECD report on Investing in Climate, Investing in Growth (2017) states that the government must design policies that will not only limit future climate damages but will also look into growth enhancement, along with mobilizing investment for developing low-carbon, climate-resilient infrastructures and technologies. Though the OECD countries have expressed their need for green financing to sustain the eco-innovation initiatives, the need is yet to be fulfilled. The OECD (2019) report on *Aligning Development Co-operation and Climate Action* states that these nations have been partially successful in mobilizing the green finances toward the development of the environmental technologies and eco-innovation solutions. However, this report has been criticized during the COP25 summit for overstating the green finance figures (Gabbatiss, 2021). This indicates the need of a policy reorientation in the OECD member countries for effective channelization of the green finances for boosting the eco-innovation initiatives, which builds the background of the present study.

The discussion on the eco-innovation and green finances in case of the OECD countries calls for the discussion on the *New Approaches to Economic Challenges* (NAEC) (OECD, 2012). A major focus of the NAEC is to reduce the policy tradeoffs in an innovation-driven trajectory and ensure inclusive growth. In this pursuit,

NAEC aims at attaining environmental sustainability, while taking care of the social issues arising out of treading along the growth trajectory. However, in 2016, an NAEC assessment report by OECD highlighted several issues pertaining to be the predicaments in the way of innovation-led environmental sustainability (Love, 2016). Amidst the social issues, the gender dimension has been given a special emphasis, as the gendered dimension of innovation was largely ignored in the OECD policy dialogue. The reason behind developing a gendered understanding of innovation is the prevalence of pervasive gender inequalities across the larger development spectrum, which include the poverty alleviation, development of inclusive society, and climate change (IDIA, 2018). To achieve sustainable development, it is necessary to restore social balance by providing equal opportunities to both men and women in access to education, employment, and health facilities. The reason is related to women's imperative role in different aspects of a society; beginning from taking household responsibilities and decisions to finding solutions to varied problems through their presence in policy forums and through entrepreneurial ventures. Therefore, to achieve sustainable development, it is essential to address gender equality. The OECD countries are experiencing gender inequality, which is evident from the fact that though more women hold university degree than men (i.e., around 46% women), only 20% of them pursue Science, technology, engineering, and mathematics (STEM) (OECD, 2017). The statistics show that after being educated, women are less likely to be part of the labor force or even to pursue self-employment. The probable reasons can be that women are paid almost 15% less than men in the same job role as well as earn minimum five times less than their male counterparts even in their entrepreneurial ventures (OECD, 2017). Hence, it is possible that women are discouraged to take any initiative in addressing environmental problems by coming up with sustainable innovative solutions. Moreover, the low participation of women in the labor force of the OECD countries might limit the cognitive capability to innovate. Hence, the attainment of SDG 13 through eco-innovations might entail addressing the inclusion of gender dimension within innovation, and thereby, a simultaneous attainment of the SDG 5 objectives, i.e., gender equality. While addressing gender equality through policy reorientation, it is essential to recognize the dominant discriminatory role of gender pay gap in the labor market. SDG 8.5 mentions about equal opportunities of decent work and equal pay irrespective of the gender. Therefore, the attainment of SDG 5 objectives will entail the attainment of the objectives of SDG 8.5. The prevailing policy framework of the NAEC has not yet accounted for the gendered dimensions to its acceptable level. From the perspective of attaining the SDG objectives, it is necessary to address the issue of gender inequality, which might consequently impede the development of the eco-innovation solutions. The inclusion of the gendered dimension in the policy dialogue of the OECD countries necessitates a policy reorientation, which is the focus of the present study. Based on this discussion, the research question of the study can be framed as per the following:

Research question: *Does the prevalence of gender inequality moderate the impact of green finance on eco-innovations in the OECD countries?*

Given the prevailing climatic condition of the OECD countries, it might be assumed that the policymakers in these countries are looking forward to a policy

reorientation for resorting the ecological balance. For internalizing the negative environmental externalities exerted by the economic growth trajectory, the policymakers need to depend on the eco-innovation solutions. The sustenance of these solutions is conditional upon the effective execution of green finance channels and maintaining gender balance within the economy. Following the green growth objective of the NAEC, the OECD countries might need to reorient the existing developmental policies to accommodate the gendered dimension. Hence, the new reoriented policy framework needs to take in the environmental and social dimensions, simultaneously. In this pursuit, the present study aims to understand how gender inequality moderates the impact of green finance on eco-innovation in case of the OECD countries. Based on the study outcomes, a new multilateral SDG-oriented policy framework is recommended for attaining the objectives of SDG 13 and SDG 5. Having focused on the SDG objectives, this new policy framework might also help this group of countries in making progress toward achieving the *Agenda 2030*. Moreover, developing a policy framework for the OECD countries might serve as a benchmark approach for the other developed and developing economies, which are also in the process of mainstreaming the gender dimension in the environmental policy framework. Grounded on the theoretical foundation of the principles of ecofeminism, the outcomes of this study can show a way to transform the innovation processes to be more gender inclusive, and thereby, can ascertain a long-term social balance. Certainly, this particular gender-inclusive policy design by encompassing green finance and eco-innovation for attaining the SDG objectives has not been adopted in the literature. The development of this new policy framework describes the policy-level contribution of the study.

During the designing of the policy framework, there is also need to consider the economic and political spillovers among the OECD member countries. The methodological adaptation needs to take care of this aspect, as disregarding this might lead to spurious model outcomes. Hence, the second-generation panel data modeling approach has been adapted in this study. Furthermore, assuming the moderating impact of gender inequality might evolve over the years, the dynamic elasticity analysis approach has been employed in deriving the model outcomes. This methodological adaptation complements the policy-level objective of the present study.

The rest of the study is designed in this manner: Section 2 reviews the relevant literature, Section 3 describes the empirical model, Section 4 discusses the model outcomes, and Section 5 concludes the study with the policy recommendation.

2. Literature review

The present study aims at analyzing the moderating impact of gender inequality on the effect of green finance on eco-innovation. In keeping with this research objective, the review of literature has been sub-divided into two sections: (a) the first section discusses the association between green financing and eco-innovation, and (b) the second section confers the association between gender and eco-innovation. At the end of both the sections, research gaps are presented.

2.1. Green financing and eco-innovation

For countries across the world, economic growth is a prerequisite for the overall development of an economy, as it helps in addressing poverty, providing quality education, assuring good health and well-being, etc. However, the traditional processes involved in economic growth are causing pressure on the environment leading to climate change and environmental degradation. To address these issues, there is need of developing environmentally sustainable strategies, which can include shift toward renewable energy usage. Nevertheless, the transition from fossil fuel to renewable energy sources can be done by implementing environment friendly innovations, which has been discussed in the literature (Lin & Ma, 2022; Nosheen et al., 2021). Eco-innovation is a long-term strategy for introducing sustainability through minimal use of natural resources and energy in the process of production that further enables reduction in environmental degradation (Suki et al., 2022;Tsai & Liao, 2017). However, there is need of sustained finance to instigate eco-innovation, wherein the role of financial sector becomes crucial. The inclusion of financial sector in the process of transition to low-carbon and resource-efficient economies for addressing climate change is referred to as Green Finance (Agirman & Osman, 2019).

The initial step of employing Green Finance is to engage the primary players of the financial sector, i.e., banks and insurance providers in making decision related to granting of loans for projects after considering their impact on the environment. Furthermore, these financial institutions must also come up with regulations for introducing environmental aspects in their credit screening system to support socially and environmentally desirable innovations (Gabbi et al., 2016). In spite of the involvement of financial institutions, the government also needs to provide funding for eco-innovation as there are risks associated with these innovations, which in turn can hamper feasibility of green projects (Yoshino et al., 2019). Government can support eco-innovation by developing Public Financial Institutions that will provide long-term loans for successful implementation of environment friendly innovations (Geddes et al., 2018). Taghizadeh-Hesary and Yoshino (2020) in their study showed that financing of renewable energy projects will ultimately promote eco-innovations because such innovations involve high risk, low rate of return, and long-term financial support. Islam et al. (2014) conducted their study on Bangladesh and highlighted the importance of green financing for facilitating eco-innovations. Another feasible way for the government to raise sustained finance for eco-innovations can be through taxation of environmental degradation itself. Bjertnaes (2021) showed that CO_2 tax component on fuel encourages purchasing of low or zero emission vehicles. However, the study by Sinha et al. (2021) also emphasized on the negative impact of green financing on environmental and social responsibility.

In the course of this review of literature, it has been largely found that the studies have analyzed the impact of green finance on eco-innovation, considering the *Ceteris Paribus* condition. It might be assumed that upon relaxation of this condition, the said impact might differ. While the literature has mainly focused on the unconditional impact of green finance on eco-innovation, the aspect of conditional impact has been largely ignored. Under the influence of social dimensions of an economy, the impact of green finance on eco-innovation might not reach its full potential, and

there lies the gap in the literature. From the policymaking perspective, addressing this gap might be crucial, as for attaining sustainable development, it is necessary for the eco-innovation to be socially inclusive, and the present study addresses this gap.

2.2. Gender and eco-innovation

Eco-innovation, as has been mentioned earlier, is a driver of economic growth and plays a crucial role in addressing societal challenges. Literature has shown an integrated relation between entrepreneurship and innovation, which helps in economic growth of a country (Grazzi, 2018). The Inter-American Development Bank (IADB) has aptly demonstrated the varied facets of innovation as: 'the execution of a new way of doing things more efficiently (a more effective use of resources); a new or significantly improved product (good or service) or process; a new marketing practice; or a new organizational method in business practices, workplace organization, or external relations' (Navarro, 2017, p.17). Considering innovation to be a driving force behind economic growth, it is also crucial to understand it using a gendered lens. The reason behind developing a gendered understanding of innovation is the prevalence of pervasive gender inequalities across the development spectrum, which include poverty alleviation, development of inclusive society, and climate change (IDIA, 2018).

Understanding the specific needs of women before developing an environment friendly innovation is crucial because household responsibilities are mainly borne by women, wherein they need to decide about the daily procurement of water, food, and cooking fuel. Therefore, any innovation must try to improve women's quality of life and income (Abreu, 2020). Furthermore, to develop an all-inclusive innovation, it is necessary to address gender discrimination in the professional world by designing gender sensitive policies that will look into the issues like work-life balance, wage gap, and working hours (Wu & Malcom, 2017). Lastly, women must be encouraged to become entrepreneurs because they have the best understanding of their problems, which they can address by making required innovations (Zastempowski & Cyfert, 2021). Moreover, studies have shown that women are sensitive toward environmental degradation and are keener toward innovation favorable for the environment (García-Sánchez et al., 2021; Mininni, 2022).

Gender diversity has positive contribution toward innovation, which has been demonstrated in several studies. Studies by Chen et al. (2018) and Galia et al. (2015) show that higher female presence among the board of directors presents higher probability of innovation that are environment friendly. Østergaard et al. (2011) also depicted that gender diversity among employees is seen to have higher possibility of encouraging innovation at the firm level. On the contrary, some studies have also shown that women are more risk averse than men, which is detrimental to innovation (Faccio et al., 2016). The reason of women leaders being averse to taking risk can be associated with the lack of financial assistance. Herein, the role of government becomes imperative to provide green finance for promoting eco-innovations that considers gender in its implementation process.

From this brief review of the literature, it can be found that the relationship between eco-innovation and gender has been analyzed from a causal point of view. Under purview of this approach, both of these policy aspects have been recursively analyzed from a demand-supply perspective. Taking a cue from the critics of the *Schumpeter's Theory of Innovation* by Sweezy (1943), it can be inferred that the innovation might be subject to the factors involved in the circular flow of economy. This hypothesized conditional impact can challenge the *fallacy of petitio principii*, which is largely referred to in the empirical literature of gender-innovation nexus as the bidirectional causation between these two aspects. Now, gendered dimensions of the economy can have a moderating impact on the innovation policies, and from the sustainable development outlook, this impact might be more crucial for the eco-innovation. There lies the gap in the literature, and the present study aims at addressing this gap.

2.3. Research gap

Through the review of literature, two distinct research gaps can be identified: (a) the impact of green finance on eco-innovation in conditional upon exogenous factors, and (b) the eco-innovation might be gender-sensitive. If both these research gaps are converged, then it might be hypothesized that gender inequality might moderate the impact of green finance on eco-innovation. In this research gap, gender inequality is taken as the gender dimension, as this particular aspect of gender can be recognized as a social imbalance. Considering the nexus between green finance and eco-innovation, this social imbalance might be taken as an exogenous factor. Addressing this phenomenon might lead to crucial policy implications for the OECD countries, as gender mainstreaming is yet to be realized in the environmental policy fora of the OECD countries. The present study addresses this research gap.

3. Model development and data

3.1. Theoretical model

A sustained financial channel is necessary to foster the innovation capabilities of a nation. And when the environmental degradation issues are concerned, majorly the green or eco-innovations come to pass. For sustaining the development and deployment of these eco- innovation initiatives, a sustained financialization channel can be designed by taxing the environmental degradation itself. Imposing the Pigouvian taxation on the processes exerting the negative environmental externalities can lead to (a) reduction in the environmental degradation, and (b) encouraging the industrial activities to embrace the eco-innovation solutions. Nevertheless, this process might require the effectives of the environmental laws and regulations. Extending the Porter's hypothesis (1991), the presence of strong institutions can help in boosting the eco-innovation. In presence of the strong institutions, the trade activities might lead to effective transaction of technologies, as the environmental laws and regulations might restrict the trade in dirtier technologies and can prevent the nations from being the pollution havens. At the same time, the prevailing economic growth

trajectory in these nations might be driven by the nature of industrialization. The environmental impact of the economic growth might be determined by this industrialization pattern. Hence, it will also drive the adaptation of the eco-innovation solutions.

While saying this, the social balance in these economies in terms of inclusiveness might play a significant role in shaping the impacts of the institutions and the economic environment. Gender inclusiveness is one of such social dimensions, as it might encompass various societal dimensions. Even after constituting nearly half of global population, women are historically discriminated in getting education, health facilities, representation in politics, and presence in the labor market, which can have negative social externalities. Gender inequality refers to this discrimination against women, i.e., the lack of equal rights and opportunities (OSAGI, 2001). Therefore, the *Gender Inequality Index* refers to the gender inequalities prevailing in the three aspects of human development, i.e., health, empowerment, and labor market.

Gaining economic freedom is one of the ways to achieve empowerment, which can be reflected through increase in female labor force participation. With a greater number of women joining the labor force, more women will have access to income, which in turn will encourage them to empower other women by providing them education and work. This will further ensure availability of more human capital. Moreover, higher income will also help women to avail better health facilities. In addition, women are the bearer of the future labor force, and so, the accessibility to the health facilities will ensure the quality of human capital. Thus, greater representation of women in the labor force might bring the flairs of cultural diversity, cognitive congruence, and better ideation. Therefore, female labor force participation is fundamental to reduction of gender inequalities and is also an important aspect of the *Gender Inequality Index*. Moreover, at the household level, women being more vulnerable to the issues of environmental degradation, discussing the gendered aspect of the eco-innovation might result in superior outcomes. Hence, in presence of gender inequality, it might be assumed that the eco-innovation might not reach its full potential.

Following this brief theoretical discussion, the functional form of the empirical framework can be outlined as the following:

$$ECOINN = f(ETAX, GII, GOV, OPEN, TRF) \tag{1}$$

In Eq. (1), ECOINN denotes eco-innovation, ETAX denotes environmental tax revenue, GII denotes gender inequality index, GOV denotes governance quality, OPEN denotes trade openness, and TRF denotes structural transformation of economy. The testable form of the Eq. (1) for i ($=1, 2, \ldots, n$) number of sample countries over t ($=1, 2, \ldots, t$) years can be described as the following:

$$ECOINN_{i,t} = \alpha_0 + \alpha_1 ETAX_{i,t} + \alpha_2 GII_{i,t} + \alpha_3 GOV_{i,t} + \alpha_4 OPEN_{i,t} + \alpha_5 TRF_{i,t} \tag{2}$$

Now, the gender inequality of a nation might influence the impacts of institutions and the economic environment on the eco-innovations. In presence of the female representation in the government and regulatory bodies, it might be difficult to bring out a wholesome policy perspective. Thereby, the gender inequality might shape the impact of institutions on the eco-innovations. Similarly, disregarding the gendered

aspects of environment might restrict the eco-innovations from reaching its full potential. Hence, the green financing of the eco-innovation projects via environmental taxation might also be affected. Furthermore, the industrial transformation pattern and technology transfer via trade might not exert the expected environmental benefits in presence of gender inequality, as the social imbalance caused by gender inequality might impede the effective reach and implementation of the developmental policies. Leaving women behind in the trajectory of industrial progression might lead to the creation of a cognitive void, which might have a negative consequence on the development and deployment of the eco-innovation solutions. Based on this insight, the Eq. (2) [hereafter Model 1] might be represented as the following:

$$
\begin{aligned}
\text{ECOINN}_{i,t} = {} & \beta_0 + \beta_1 \text{ETAX}_{i,t} + \beta_2 \text{GII}_{i,t} + \beta_3 \text{GOV}_{i,t} + \beta_4 \text{OPEN}_{i,t} + \beta_5 \text{TRF}_{i,t} + \text{GII}_{i,t} \\
& * (\beta_6 \text{ETAX}_{i,t} + \beta_7 \text{GOV}_{i,t} + \beta_8 \text{OPEN}_{i,t} + \beta_9 \text{TRF}_{i,t})
\end{aligned}
$$

$$(3)$$

$$
\begin{aligned}
\text{ECOINN}_{i,t} = {} & \gamma_0 + \gamma_1 \text{ETAX}_{i,t} + \gamma_2 \text{GII}_{i,t} + \gamma_3 \text{GOV}_{i,t} + \gamma_4 \text{OPEN}_{i,t} + \gamma_5 \text{STR}_{i,t} + \text{GII}_{i,t} \\
& * (\gamma_6 ETAX_{i,t} + \gamma_7 GOV_{i,t} + \gamma_8 OPEN_{i,t} + \gamma_9 TRF_{i,t}) + \text{GII}_{i,t} * \text{ETAX}_{i,t} \\
& * (\gamma_{10} \text{GOV}_{i,t} + \gamma_{11} \text{OPEN}_{i,t} + \gamma_{12} \text{TRF}_{i,t})
\end{aligned}
$$

$$(4)$$

Now, from Eq. (3) and (4) [hereafter Model 2 and 3, respectively], the gender inequality is found to moderate the impacts of institutions and the economic environment on the eco-innovations. These moderating impacts can be represented in terms of the elasticity of eco-innovation with respect to environmental tax revenue, as shown:

$$
\frac{\partial ECOINN_{i,t}}{\partial ETAX_{i,t}} = \begin{cases} Model\ 1: & \alpha_1 \\ Model\ 2: & \beta_1 + \beta_6 * GII_{i,t} \\ Model\ 3: & \gamma_1 + GII_{i,t} * (\gamma_6 + \gamma_{10} GOV_{i,t} + \gamma_{11} OPEN_{i,t} + \gamma_{12} TRF_{i,t}) \end{cases}
$$

This elasticity terms derived from the three empirical models bring forth certain conditions:

$$\text{Condition 1}: \quad \alpha_1 > \beta_1 + \beta_6 * \text{GII}_{i,t}$$

$$\text{Condition 2}: \quad \alpha_1 < \beta_1 + \beta_6 * \text{GII}_{i,t}$$

$$\text{Condition 3}: \quad \alpha_1 = \beta_1 + \beta_6 * \text{GII}_{i,t}$$

$$\text{Condition 4}: \quad \alpha_1 > \gamma_1 + \text{GII}_{i,t} * (\gamma_6 + \gamma_{10} \text{GOV}_{i,t} + \gamma_{11} \text{OPEN}_{i,t} + \gamma_{12} \text{TRF}_{i,t})$$

$$\text{Condition 5}: \quad \alpha_1 < \gamma_1 + \text{GII}_{i,t} * (\gamma_6 + \gamma_{10} \text{GOV}_{i,t} + \gamma_{11} \text{OPEN}_{i,t} + \gamma_{12} \text{TRF}_{i,t})$$

Condition 6 : $\alpha_1 = \gamma_1 + \text{GII}_{i,t} * (\gamma_6 + \gamma_{10}\text{GOV}_{i,t} + \gamma_{11}\text{OPEN}_{i,t} + \gamma_{12}\text{TRF}_{i,t})$

Condition 7 : $\beta_1 + \beta_6 * \text{GII}_{i,t}$
$> \gamma_1 + \text{GII}_{i,t} * (\gamma_6 + \gamma_{10}\text{GOV}_{i,t} + \gamma_{11}\text{OPEN}_{i,t} + \gamma_{12}\text{TRF}_{i,t})$

Condition 8 : $\beta_1 + \beta_6 * \text{GII}_{i,t}$
$< \gamma_1 + \text{GII}_{i,t} * (\gamma_6 + \gamma_{10}\text{GOV}_{i,t} + \gamma_{11}\text{OPEN}_{i,t} + \gamma_{12}\text{TRF}_{i,t})$

Condition 9 : $\beta_1 + \beta_6 * \text{GII}_{i,t}$
$= \gamma_1 + \text{GII}_{i,t} * (\gamma_6 + \gamma_{10}\text{GOV}_{i,t} + \gamma_{11}\text{OPEN}_{i,t} + \gamma_{12}\text{TRF}_{i,t})$

These conditions reveal the possible characteristics of the moderating impact of the gender inequality. Condition 1 and 2 show the dampening and boosting moderating effects of the gender inequality, respectively. The condition 3 indicates no moderating effect of the gender inequality. Similarly, condition 4 and 5 also show the dampening and boosting moderating effects of the gender inequality, while condition 6 indicates the sign of indifference. Lastly, condition 7 and 8 show the dampening and boosting moderating effects of the gender inequality on the impacts of institutions and the economic environment, while condition 9 indicates the sign of indifference. Empirically analyzing these conditions might illustrate the possible policy intervention points in the sample countries for including the gender aspects in developing the eco-innovation solutions.

The structural transformation of economy (TRF) is computed by the Lilien Index (1982), which captures the changes in labor share across primary, secondary, and tertiary sectors. It can be represented as follows:

$$\text{TRF}_{i,t} = \sqrt{\sum_{c=1}^{3}\left(\frac{\text{LS}_{c,t}}{\text{LS}_t}\right)(\Delta\log\ \text{LS}_{c,t} - \Delta\log\ \text{LS}_t)^2} \tag{5}$$

Here, LS is share of labors in a particular sector, and c (= 1, 2, 3) shows the primary, secondary, and tertiary sectors, respectively.

3.2. Data

The study is conducted for 38 Organisation for Economic Co-operation and Development (OECD) countries[1] over 1994–2019. The data of the environment-related technologies (proxy for eco-innovation) and the environmentally related tax revenue (proxy for green finance) are collected from website of OECD statistics. The data on gender inequality index have been collected from the United Nations Development Programme (UNDP). The data on trade openness (in PPP dollar terms), labor force (total) and the number of labors in three sectors (agricultural, industrial, and service) have been collected from the World Development Indicators

(World Bank, 2021a). The data on governance quality have been collected from the Worldwide Governance Indicators (World Bank, 2021b).

3.3. Methods

As the OECD countries might be associated with each other via trade and economic spillovers, the estimation methods need to take account of this aspect. Therefore, at the outset, the cross-sectional dependence test is used for identifying the dependence structure of the cross sections in the data. Assuming the hypothesized association between the OECD countries holds true, the second-generation panel data-based methodological approach should be adopted, as this approach assumes the cross-sectional dependence in the data. To check the integration property of the model parameters, Cross-sectionally augmented Im-Pesaran-Shin and the Cross-sectionally augmented Dickey-Fuller tests are applied. Upon finding the integration property of the model parameters, it is necessary whether the model parameters will coexist in the long run, and second-generation cointegration test is applied in order to assess. The Westerlund (2007) cointegration test has solved the purpose of evaluating the cointegrating association among the model parameters. Lastly, the long run coefficients are estimated using the Common Correlated Effects method. The coefficients were further used to determine the elasticity of the moderators, so that the evolution of their marginal impacts can be captured.

4. Discussion of results

In order to proceed with the analysis, first the initial diagnostics of the model parameters are carried out, so that the systematic flow of the methodological application can be justified. In this pursuit, the Chudik and Pesaran (2015) weak cross-sectional dependence test is employed. The test outcomes reported in Table 1 suggests that the model parameters are dependent across the cross-sections of the data. This scenario fulfills the basic assumption of the second-generation panel data modeling approach. Hence, the subsequent tests are second-generation in nature.

Ensuing the evidence of cross-sectional dependence, the second-generation panel unit root tests are carried out. These tests validate the stationarity property of the model parameters, and check whether the roots of the characteristic equation of the empirical model are inside the unit circle, or not. Following Pesaran (2007), the outcomes of the Cross-sectionally augmented Im-Pesaran-Shin (CIPS) and the Cross-sectionally augmented Dickey-Fuller (CADF) tests reported in Table 2 designate that the model parameters reveal the stationarity property after the first differentiation.

Table 1. Cross-sectional dependence test outcomes.

Variables	Test Statistics	Variables	Test Statistics
ECOINN	130.982***	OPEN	135.103***
ETAX	134.722***	GOV	114.341***
GII	133.586***	TRF	128.033***

Note: ***denotes $p \leq 0.01$.
Source: Authors' own calculation.

Table 2. Second-generation unit root test outcomes.

	CIPS		CADF	
	Level	First Difference	Level	First Difference
ECOINN	−1.378	−4.552***	−1.851	−3.917***
ETAX	−1.429	−4.082***	−1.869	−3.369***
GII	−0.930	−1.681**	−0.880	−1.899**
OPEN	−1.961	−4.097***	−1.749	−−3.011***
GOV	−1.814	−4.944***	−1.593	−3.570***
TRF	−1.186	−4.424***	−1.143	−4.824***

Note: ***denotes $p \leq 0.01$, **denotes $0.01 < p \leq 0.05$.
Source: Authors' own calculation.

Table 3. Second-generation cointegration test outcomes.

Statistics	Value	Z-value	P-value	Robust P-value
Gt	−1.532	2.680	0.996	0.070
Ga	−3.320	5.685	1.000	0.000
Pt	−8.740	0.968	0.833	0.004
Pa	−3.053	2.581	0.995	0.000

Note: 1000 bootstrap replications are performed.
Source: Authors' own calculation.

Acceptance of the alternate hypothesis of the incidence of difference stationarity allows the use of the second-generation cointegration test.

Incidence of the difference stationarity after the first differentiation specifies that the model parameters are first-order integrated. This outcome warrants the assessment of a probable long run association among the model parameters, in presence of the cross-sectional dependence. In this pursuit, the outcomes of Westerlund (2007) cointegration test reported in Table 3 show that the model parameters are cointegrated in presence of cross-sectional dependence.

4.1. Discussion of the individual impacts

Once the initial diagnostic tests on the empirical model have shown favorable outcomes, long run coefficients of the empirical model will be estimated. As the cross-sectional dependence is present in the data, long run coefficients are estimated using Common Correlated Effects procedure (Pesaran, 2006). The test outcomes are reported in Table 4, and the individual impacts of the explanatory variables are captured in Model 1. The test outcomes denote that the environmental tax revenue has a positive impact on the eco-innovation. The expansion of green finance in the OECD countries has a catalyzing effect on the eco-innovation projects. This result is an extension of the findings by Abbasi et al. (2022). However, it is worthwhile to note that the coefficient is less than one, and it signifies that the growth in the green finance is not yet commensurate to development of eco-innovation initiatives. The *Forum of Green Finance and Investment 2020* held by the OECD Environment Directorate discussed about the shortcoming of the green finances available for the ongoing innovation activities in the OECD member countries (OECD, 2020). In order to mobilize the finances, the forum criticized the existing innovation policies, and recommended a policy reorientation. The study outcome corroborates to this scenario. This piece of the evidence can be significant in view of the estimated impact

Table 4. Long run coefficient estimation outcomes.

	Model 1	Model 2	Model 3
ETAX	0.822**	2.023***	1.424***
GII	−0.998***	−0.682*	−0.707*
OPEN	0.691**	0.833*	1.457***
GOV	0.265**	1.538***	1.514***
TRF	−0.587*	−0.506**	−0.557*
GII * ETAX	–	1.137***	0.409**
GII * OPEN	–	0.407*	0.352
GII * GOV	–	0.825**	0.799**
GII * TRF	–	0.415**	0.688*
GII * ETAX * OPEN	–	–	0.072*
GII * ETAX * GOV	–	–	0.009
GII * ETAX * TRF	–	–	−0.030**

Note: ***denotes p ≤ 0.01, **denotes 0.01 < p ≤ 0.05, *denotes 0.05 < p ≤ 0.10.
Source: Authors' own calculation.

of the governance quality. Following the Porter's Hypothesis (1991), the impact of governance quality on eco-innovation is expected to be positive. Sinha and Rastogi (2017) found similar evidence in case of India. The OECD countries are no exception to this, and this argument is validated by the coefficient of governance quality. However, the coefficient is less than half, and it signifies that the improvement in the governance quality is yet to be proportionate to the development of the eco-innovation initiatives. It might be possible the presence of stringent environmental regulations, the entrepreneurship ventures towards the development of the eco-innovation capabilities might not flourish. This issue was identified in the OECD (2011) report on green growth assessment, while stating the regulatory stringency being a major reason behind the slow diffusion of eco-innovation initiatives. In a recent report by Hughes et al. (2020) states the necessity of institutional deepening for boosting the eco-innovation capabilities. A scenario of the similar kind has been reported by Godil et al. (2021). This indicates the need to institutional reorientation for encouraging the eco-innovation initiatives. Now, for promoting eco-innovation, environmental technologies are required. The international trade route might be utilized for this purpose. The cleaner and green technologies imported via the international trade route adds to the capacity building for eco-innovation, and this statement is validated by the study outcomes. This finding falls in the similar lines with the results reported by Alola et al. (2021). An assessment report by UNEP (2018) on the trade on environmental technologies substantiate this claim. However, as exogenous dependence on technological development based on this route might not be sustainable in nature, the OECD countries need to ponder upon strengthening their cognitive abilities to innovate.

While talking about building the cognitive abilities, the composition of the labor force needs to be considered. Inherent gender disparity of the OECD member countries might limit this ability. The study outcomes show that the impact of gender inequality on eco-innovation is negative. The report on *Digital Gender Divide* by OECD (2018) has shown that the digital transformation of the economies is bringing forth a gender divide. As a result, the cognitive void created in the innovation space is leading to the loss of both social and economic values. The falling participation of women in STEM might result in the loss of socio-economic dimensions of the eco-

Table 5. Changes in elasticity of eco-innovation with respect to environmental tax revenue.

	Model 1	Model 2	Model 3
Total effect of ETAX	0.822	0.112	0.055
Interaction effects			
Interacting with GII	–	−1.911	−1.369
Interacting with GII and OPEN	–	–	0.323
Interacting with GII and GOV	–	–	0.011
Interacting with GII and TRF	–	–	0.071

Note: elasticities are calculated at the sample means.
Source: Authors' own calculation.

innovation. A discussion on *Building a Gender-Equal Recovery* hosted by OECD (2021b) forum has pointed out wage rate differential to be a major cause behind this rising inequality. Though *Equal Pay International Coalition* (EPIC) was formed by the OECD, International Labour Organization (ILO), and UN Women, with an aim to bridge this gap, the outcome of this initiative is yet to be realized in terms of the attainment of SDG 8.5, i.e., equal pay for men and women. As a result, the gender disparity is prevailing in the OECD countries, and the cognitive void in the STEM domain is pulling back the innovation capability of these nations. This aspect needs critical attention of the policymakers. Moreover, the industrial transformation in the OECD countries is majorly driven towards manufacturing, where the usage of fossil fuel-based energy solutions is still predominant. Hence, the demand for eco-innovation solutions is not boosted by the industrialization pattern. A rise in this demand was experienced following the introduction in the SDGs, and this aspect was first discussed in the *Inclusive and Sustainable Industrial Development* report by United Nations Industrial Development Organization (UNIDO) (2018). Last, in 2020, in a consecutive report by UNIDO (2020), a similar finding was also reported. This argument is validated by the study outcomes, i.e., the structural transformation of economy is found to have a negative impact on the eco-innovation. In order to restore environmental balance, the policymakers of the OECD countries need to imbibe the elements of sustainability in the industrial transformation pattern.

4.2. Discussion of the interactive impacts

Discussion of the individual impacts of the model parameters on the eco-innovation needs to be carried out alongside discussing the interactive impacts. The interaction effects might reveal additional details about the impact of green finance on eco-innovation, in presence of gender inequality and other model parameters. Based on the coefficients reported in Table 4, the elasticities of eco-innovation with respect to environmental tax revenue are reported in Table 5. The elasticity values are reported in terms of the *Total effect* and the *Interaction effects*.

The total effect of environmental tax revenue for Model 1 is 0.822. Comparing this value with the total effect for Model 2 (=0.112) reveals that gender inequality diminishes the impact of the environmental tax revenue. While the total effect in Model 2 is reduced, the interaction effect of gender inequality is found to be negative. It signifies that while the environmental tax revenue was having a positive impact on the eco-innovation, the incidence of gender inequality dampened that impact. This scenario can be explained mathematically:

Table 6. Changes in elasticity of eco-innovation with respect to other model parameters.

	Model 1	Model 2	Model 3
Total effect of OPEN	0.691	0.149	0.049
Total effect of GOV	0.265	0.151	0.067
Total effect of TRF	−0.587	−1.204	−1.378

Note: elasticities are calculated at the sample means.
Source: Authors' own calculation.

$$\text{Total effect (Model 1)}: \ \alpha_1 \ = \ 0.822$$

$$\text{Total effect (Model 2)}: \ \beta_1 + \beta_6 * GII_{i,t} \ = \ 0.112$$

$$\text{Interaction effect (Model 2)}: \ \beta_6 * GII_{i,t} = \ -1.911$$

$$\therefore \alpha_1 > \beta_1 + \beta_6 * GII_{i,t} \tag{6}$$

Eq. (6) denotes the fulfillment of *Condition 1*, i.e., in presence of the gender inequality, the environmental tax revenue starts losing its potential impact on eco-innovation.

Now, the interactive impacts in case of Model 3 will be analyzed. Comparing the total effect for Model 1 with the one for Model 3 (=0.055) reveals that gender inequality diminishes the impact of the environmental tax revenue, even in presence of other model parameters. It signifies that even in presence of other model parameters, presence of gender inequality can cause more harm to the green financing of eco-innovation. This scenario can be explained mathematically:

$$\text{Total effect (Model 1)}: \ \alpha_1 \ = \ 0.822$$

$$\text{Total effect (Model 3)}: \ \gamma_1 + GII_{i,t} * (\gamma_6 + \gamma_{10}GOV_{i,t} + \gamma_{11}OPEN_{i,t} + \gamma_{12}TRF_{i,t})$$
$$= \ 0.055$$

$$\text{Interaction effect (Model 3)}: \ GII_{i,t} * (\gamma_6 + \gamma_{10}GOV_{i,t} + \gamma_{11}OPEN_{i,t} + \gamma_{12}TRF_{i,t})$$
$$= \ -1.369$$

$$\therefore \alpha_1 > \gamma_1 + GII_{i,t} * (\gamma_6 + \gamma_{10}GOV_{i,t} + \gamma_{11}OPEN_{i,t} + \gamma_{12}TRF_{i,t}) \tag{7}$$

Eq. (7) denotes the fulfillment of *Condition 4*, i.e., in presence of the gender inequality, the environmental tax revenue starts losing its potential impact on eco-innovation, even in presence of other model parameters.

Now, it's worthwhile noting that negative interactive effect of gender inequality is reduced, while the total effect of environmental tax revenue is also reduced. It signifies that the effects of other model parameters might also have endured a change. The elasticity values of trade openness, governance quality, and structural transformation of economy are reported in Table 6. The outcomes show that the reduction in
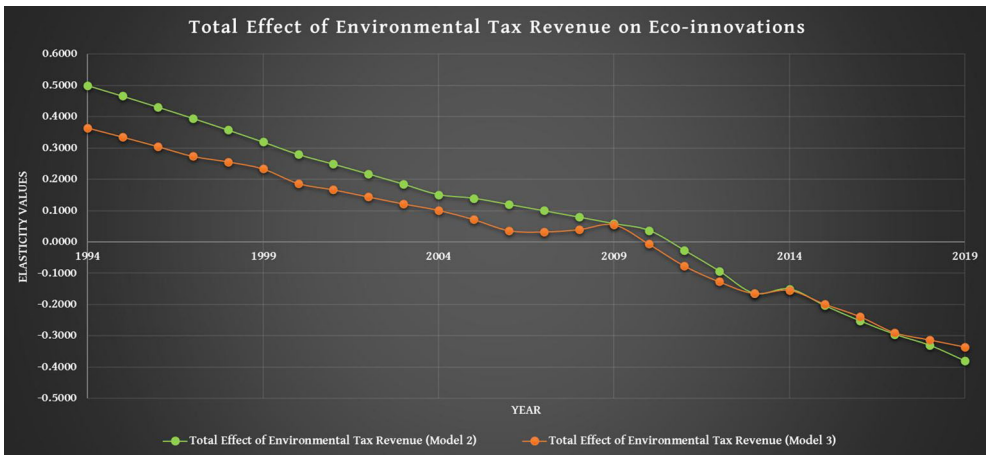
Figure 1. Trend of total effect of environmental tax revenue on eco-innovation.
Source: Authors' own calculation.

the positive impacts of trade openness and governance quality coexist with the rise in the negative impact of structural transformation of economy. In presence of gender inequality, these model parameters might have started experiencing a fall in their potential boosting impact on the eco-innovation. Therefore, while the interaction effect of gender inequality shown a decline, the total effect shown a decline, rather than showing improvement. This scenario can be explained mathematically:

$$\text{Total effect (Model 2)}: \ \beta_1 + \beta_6 * \text{GII}_{i,t} \ = \ 0.112$$

$$\text{Total effect (Model 3)}: \ \gamma_1 + \text{GII}_{i,t} * (\gamma_6 + \gamma_{10}\text{GOV}_{i,t} + \gamma_{11}\text{OPEN}_{i,t} + \gamma_{12}\text{TRF}_{i,t})$$
$$= \ 0.055$$

$$\therefore \beta_1 + \beta_6 * \text{GII}_{i,t} > \gamma_1 + \text{GII}_{i,t} * (\gamma_6 + \gamma_{10}\text{GOV}_{i,t} + \gamma_{11}\text{OPEN}_{i,t} + \gamma_{12}\text{TRF}_{i,t}) \tag{8}$$

Eq. (8) denotes the fulfillment of *Condition 7*, i.e., in presence of the gender inequality, the other model parameters start losing their potential impact on eco-innovation.

Now, it's worth noting that the elasticities were computed at the sample mean to observe the moderating impact of the gender inequality, under the assumption of central tendency. However, this assumption might not be realistic, as the said moderating impact might differ at the tails of the distribution. In order to capture this aspect, the total effects are computed over the entire time period, and the elasticity values are plotted in Figure 1. It is visible that the total effect of environmental tax revenue on eco-innovation is negatively moderated by gender inequality, and the negative impact is increased over time. However, the figure also reveals that the total effect of environmental tax revenue for Model 3 has surpassed that of Model 2 since 2015. It indicates that the institutional and economic environment is becoming more socially-inclusive with the graduation of time. This piece of evidence indicates that if
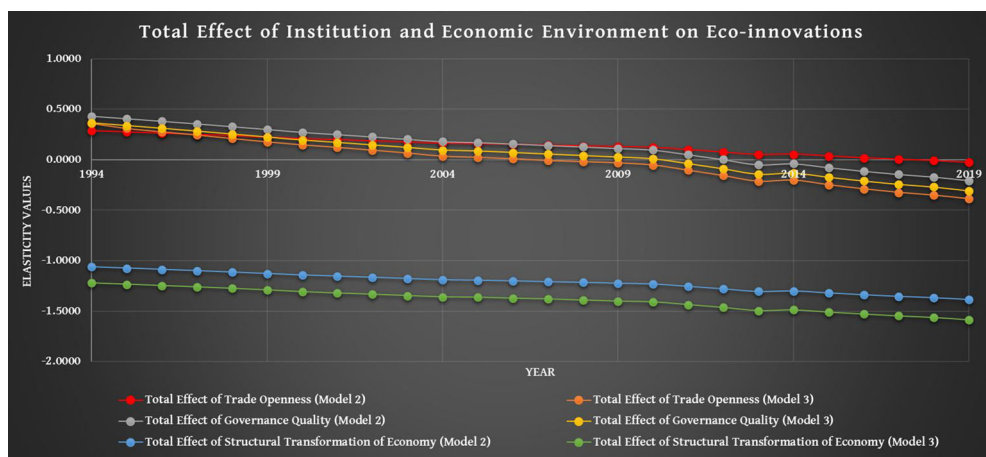
Figure 2. Trend of total effects of institution and economic environment on eco-innovation.
Source: Authors' own calculation.

this situation prevails, application of a reoriented policy framework might restore the social balance gradually, while improving the development and deployment of eco-innovation. However, the effects of institutional and economic environment on eco-innovation plotted in Figure 2 reveal that their impacts are dampened in presence of gender inequality, and this dampening in increasing over time. This evidence demonstrates the need of an early policy intervention in the OECD countries for restoring the social balance by mainstreaming gender aspects in the environmental policies.

5. Conclusion and policy implications

By far, the moderating impact of gender inequality on the impact of green finance on eco-innovation for the OECD countries is assessed over 1994–2019. Using panel data modeling and dynamic elasticity analysis, the gender inequality is found to dampen the impact of green finance on eco-innovation. Based on the study outcomes, a policy framework is suggested for the OECD countries.

5.1. Core policy framework

In order to improve the gender mainstreaming, the policymakers need to introduce requisite policy interventions. The policymakers need to pass a legislation that the industrial sector need to maintain equal pay for both men and women. However, passing the legislation might not be the only solution, as the equalization might not be an automatic process. Equalizing the pay structure might have negative consequences on the cash flow structure of the firms. A cascading effect of this very scenario might harm the economic growth trajectory at large. Hence, the policymakers need to adapt a phase-wise policy design approach. While designing the phases, the policymakers also need take care of financing the eco-innovation solutions. So, the policy framework needs to take care of this dual objective simultaneously.

Revamping the pay structure and increasing the demand for eco-innovation solutions need funding. The government need to use the environmental tax revenue collection to finance these two objectives. In order to use this tax revenue, the policymakers might need to utilize the existing financial institutions to disburse these funds against differential lending rates. These funds will serve two purposes: (a) help the firms to have a temporary loan for giving the salary differential to the female workers, and (b) procuring environmental technologies or funding the eco-innovation development projects. The environmental technologies might be imported from other nations, as achieving the economies of scale might not be possible given a short span of time. Now, given the firms have to comply with these two objectives within a predetermined timeframe, the lending rate mechanism can act as the policy instrument. The financial institutions might charge differential lending rates from firms based on (a) gender wage gap, and (b) carbon footprint, i.e., the firms with higher gender wage gap or/and carbon footprint will have to face higher lending rate. This financing mechanism will gradually encourage the firms to imbibe equality in wage and embrace cleaner technologies. This financing mechanism might work as an enabler to address both these objectives simultaneously. This policy design might be considered as the first phase of the policy framework.

Nevertheless, without the support from institutional and economic environment, the policy solutions recommended during the first phase of the framework might be unsustainable. Hence, in the second phase, the realignment in institutional and economic environment will be carried out. One of the measures in the first phase was to import the environmental technologies. This measure will have a negative impact on the trade balance of the countries, and a consequential negative impact on the growth pattern. Consequently, the institutional measures need to be designed in a way to internalize these aspects, without harming the economic growth pattern. In this pursuit, the policymakers might need to consider import substitution for the inflow of technologies. This move might create an additional demand of the cleaner technologies, which will in turn boost the organically developed eco-innovation solutions. Being technologically driven, the industrial transformation in these economies might also be towards being service-oriented from manufacturing-oriented. This structural transformation of these economies will help in achieving energy efficiency by means of the eco-innovation solutions. This policy move might be considered as the second phase of the policy framework.

Once these two phases of policy framework are active, the gender wage gap is expected to shrink, and it might lead to reduction in gender inequality. Hence, this policy framework might help the OECD member countries in achieving the objectives of SDG 5. Along with this, the continuous development of eco-innovation capabilities will also help these countries in achieving the reduction in environmental degradation. Hence, these countries will be to make a progression towards the attainment of SDG 13.

5.2. Tangential policy framework

The core policy framework needs a support mechanism for its sustenance, and this support mechanism will be provided by the tangential policy framework. This

framework can be designed by logically extending the study outcomes. Once the OECD member countries are in pursuit of achieving technological advancement, the eco-innovation solutions will help in sustaining the ecological balance. These solutions are vital for the sustainable development of these nations. As the OECD countries are in the quest of developing these solutions, the infrastructure will become more resilient, more inclusive, and an environment for fostering the innovation capabilities will be developed. This policy move might be considered as the third phase of the policy framework, and it might help the OECD countries in attaining the objectives of SDG 9, i.e., industry, innovation, and infrastructure. At the same time, the shrinking wage pay gap between men and women will ensure the economic growth pattern to be inclusive. This might help the OECD countries in attaining the objectives of SDG 8, i.e., decent work and economic growth.

5.3. Limitations and future projections

In the present study, the moderating impact of gender on the impact of green finance on eco-innovation is analyzed for the OECD countries. The empirical model has considered only the institutional and economic environment factors. The gendered dimension of the eco-innovation might be politically driven also, and this aspect has been ignored in the present study. Moreover, the OECD countries are an agglomeration of developing and developed countries. Hence, a disaggregated analysis of the test outcomes could have brought forth additional insights regarding the policy framework. In view of these shortcomings, it might appear that the policy framework has certain limitations. Saying this, it also needs to be mentioned that the policy framework recommended in the present study can be considered as a benchmark for those countries, which are also struggling in gender mainstreaming. The policy framework is flexible, and hence it can be tailor-made in accordance with the context setting. This aspect of generalizability can define the contribution of the present study. Further studies in this aspect can be carried out by considering the stringency aspect of the policymaking, while accounting for the country-level disaggregated analysis of the gendered impact.

Note

1. Australia, Austria, Belgium, Canada, Chile, Colombia, Costa Rica, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Lithuania, Latvia, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States.

Disclosure statement

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