The Impact of Nonlinear Fiscal Decentralization, Green Energy, and Policy Uncertainty on Sustainable Environment? A New Perspective From Ecological Footprint in Five OECD Countries

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The Impact of Nonlinear Fiscal Decentralization, Green Energy, and Policy Uncertainty on Sustainable Environment? A New Perspective From Ecological Footprint in Five OECD Countries

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Abstract

The paper explores the short-run and long-run asymmetric impact of fiscal decentralization, green energy, and economic policy uncertainty on environmental sustainability proxied by ecological footprint. Using the Nonlinear Autoregressive Distributed lag (NARDL) approach in selected five OECD countries, we find that ecological footprint responds to positive and negative fiscal decentralization asymmetrically in the long run and short run. However, the nature of the response varies significantly across countries. The result also suggests that green energy is a major factor in reducing the ecological footprint in all countries except Canada. Finally, economic policy uncertainty plays a negative and significant role in the ecological footprint in the UK, US, and Germany while insignificant in Australia and Canada. Implications for effective environmental policies are discussed.

Keywords: Fiscal Decentralization, Green Energy, Economic Policy Uncertainty, OECD, Environmental sustainability, Asymmetric.

1. Introduction

Since the World Earth Summit in Kyoto, Japan 1997, creating a sustainable environment has become a significant world issue in the global context. The summit initiated the need to protect our planet from the global environmental crisis. Approximately 80% of the world's population lives in a country plagued by major ecological issues. Human living standards and well-being have risen dramatically in recent decades because of significant economic expansion and prosperity (Majeed et al., 2021). This puts strain on the ecosystem, resulting in emissions, biodiversity loss, and environmental imbalance (Ahmed & Wang, 2019; D. Lin et al., 2015; D. Lin et al., 2018; Vetter et al., 2014). Therefore, formulating and achieving sustainable environmental objectives becomes a top priority agenda to be addressed globally.

Scholars recently have introduced several factors that can contribute to a sustainable environment; which include fiscal decentralization (H. Chen *et al.*, 2018; Hao *et al.*, 2020; Ji *et al.*, 2021; Shi *et al.*, 2018), green energy (Adams *et al.*, 2020; Charfeddine & Kahia, 2019; de Souza *et al.*, 2018; Majeed & Luni, 2019; Öztürk *et al.*, 2020; Rasoulinezhad & Saboori, 2018; Riti & Shu, 2016), and reducing economic policy uncertainty (Adedoyin & Zakari, 2020; Anser *et al.*, 2021; Pirgaip & Dinçergök, 2020; Ulucak & Khan, 2020; Q. Wang *et al.*, 2020; Yu *et al.*, 2021) as an important factor to preserve our planet and thereby creating a sustainable environment.

Fiscal decentralization has occupied a central place in international economic patterns (L. Wang & Lei, 2016). It is a process of decentralization or power delegation to local political authorities to consider controlling important political and economic decisions in the best interest of economic objectives (Hao et al., 2020). There are two approaches responsible for this contradictory association between fiscal decentralization and environmental quality. One is the “Race to Bottom” hypothesis, and the other one is the “Race to Top” hypothesis. Fiscal decentralization is a major determinant of environmental degradation (X. Liu et al., 2017a; Que et al., 2018), and the “Race to Bottom” hypothesis is responsible for the positive association where governments encourage the relaxation of environmental regulatory norms, resulting in a reduction in environmental quality (X. Chen & Chang, 2020; L. Liu *et al.*, 2019; K. Zhang *et al.*, 2017). On the contrary, Hao et al. (2020), S. Cheng et al. (2020), and K. Li et al. (2020) believe that the “Race to the Top” hypothesis is responsible for the negative association between fiscal decentralization and environmental degradation.

Green energy is an essential factor in evaluating environmental sustainability. The gradual shift from non-renewable to renewable energy solutions leads to continuous improvement in environmental sustainability. Thus to promote renewable energy and eco-friendly energy consumption is need of the hour to achieve economic-cum-environmental goals and objectives (Charfeddine & Kahia, 2019; de Souza et al., 2018; Lau et al., 2018; Ridzuan et al., 2020; Riti & Shu, 2016; Samuel Asumadu Sarkodie et al., 2020; Sharif et al., 2019; Z. Wang et al., 2018; K. Zhang et al., 2017).

Apart from the role of fiscal decentralization and green energy, economic policy uncertainty has gained the central position in economic-cum-environmental objectives (Baker et al., 2016). Thus, the ambiguity surrounding governmental policies, particularly fiscal and monetary policies, that affects the economic environment in which businesses operate is called (EPU) economic policy uncertainty (Pirgaip & Dinçergök, 2020). However, COVID-19 has recently produced a great deal of economic uncertainty worldwide (Altig et al., 2020). Literature shows the positive association between environmental degradation and monetary policy uncertainty and determines that economic policy uncertainty is a significant and positive determinant of ecological degradation (Adams et al., 2020; Jiang et al., 2019; Q. Wang et al., 2020).

However, the current literature can be criticized for failing to capture the whole aspects of a sustainable environment because of the extensive use of CO2 emission as a proxy. This proxy has recently been questioned because it is not comprehensive as the individual impact on the environment is not considered. As a result, the focus has switched to ecological footprint as a superior proxy (Ahmed et al., 2020; Andrew A Alola, 2019; Andrew Adewale Alola & Alola, 2018; Andrew Adewale Alola, Bekun, et al., 2019; Baccini & Brunner, 2012; Barrett & Scott, 2003; Bello et al., 2018; Charfeddine & Mrabet, 2017; Dogan et al., 2019; S. Nathaniel & Khan, 2020; Ulucak & Bilgili, 2018J. Wang & Dong, 2019; Zahra et al., 2021). The ecological footprint combines the two concepts to address the damage caused by human activities at the ground level and the damage caused by the unreturned use of all of the Earth's natural resources.

Moreover, the ecological footprint is also regarded as a measure of environmental sustainability (Destek & Sinha, 2020).

The core objective of this study is to empirically investigate the impact of green energy, economic policy uncertainty, and asymmetric effects of fiscal decentralization on the ecological footprint in the United States of America, United Kingdom, Germany, Australia and Canada, the OECD counties, as explained in Fig: 1. These countries are highly decentralized OECD countries in which Germany, Australia, and Canada, during the last three decades, shifted from centralized to highly decentralized status. Even these three countries are included in the top seven decentralized countries, which have an average fiscal decentralization ratio of more than 58% in 2018, greater than the average ratio of fiscal decentralization of the rest of the world (Shan *et al.*, 2021). Secondly, while keeping the effects of environmental convergence in mind; the USA is 2nd top CO_2 emitter in the World, while Australia, Germany and Canada are included in the list of top fifteen CO_2 emitters of the World. Thirdly, these developed countries can achieve SDGs to bring forward socio-political and environmental economic objectives and synergy (Destek & Sinha, 2020). These reasons create room to investigate the association between fiscal decentralization, clean energy, economic policy uncertainty, and environmental sustainability in these five selected OECD countries.

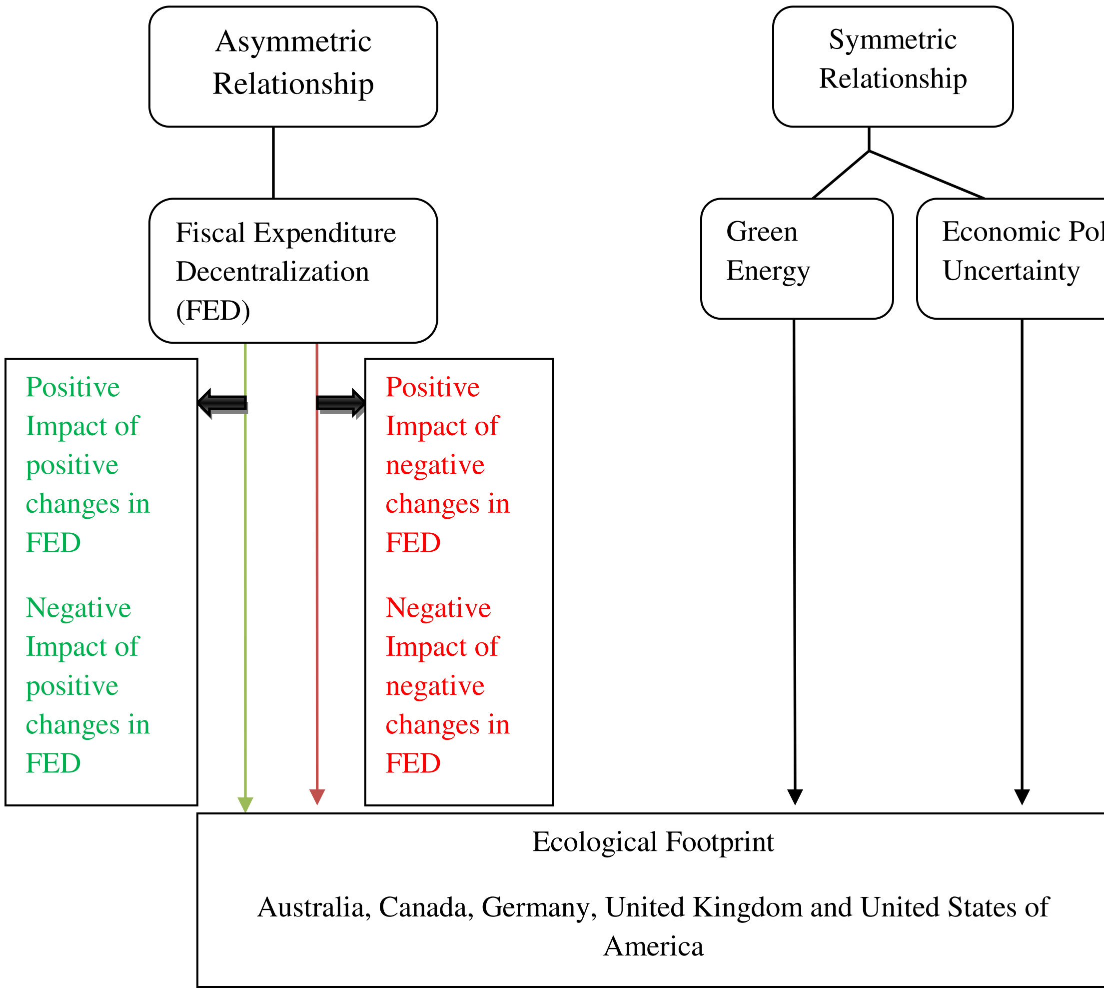

Fig.1 Objectives of the study

The current study adds to the previous literature in two ways. First, most research in the literature has analyzed the symmetrical empirical association between fiscal decentralization and the environment, using variables such as fiscal expenditure decentralization and fiscal revenue decentralization, and environmental emissions. The present study fills the existing gap by determining the asymmetric or nonlinear impact of fiscal expenditure decentralization on environmental sustainability for selected OECD countries. Secondly, most previous research studies employed CO2 emissions as a proxy for environmental degradation; this study approximates the ecological footprint to measure environmental quality.

Moreover, Policymakers, environmentalists, and government officials will benefit from the results of this study, which provide a deeper understanding and critical information, consequences, and evidence for environmental protection. The literature on fiscal decentralization, green energy, and economic policy uncertainty concerning their impact on the environment is briefly examined in section 2. We cover the model, data, and methodology in section 3. Empirical findings and their interpretation will be discussed in section 4. Finally, we conclude the results and policy implications in section 5.

2. Literature Review

2.1. Fiscal Decentralization and Environmental Degradation

Fiscal decentralization is a practice in which regional or provincial governments are given allocated authority or control over the regional economic activity (Hao *et al.*, 2020; L. Liu *et al.*, 2019). Therefore, fiscal decentralization has been documented as a global trend during the past several decades (L. Wang & Lei, 2016). Furthermore, studies indicate that fiscal decentralization can, directly and indirectly impact environmental quality (Li *et al.*, 2021). The research shows as fiscal decentralization draw its impact on economic growth and development, which in return draws its influence on environmental quality and environmental degradation. Thus there is an indirect correlation between environmental quality and fiscal decentralization. Contrary, the literature also demonstrates that fiscal decentralization directly impacts environmental protection and quality. Shi *et al.* (2018); L. Wang and Lei (2016) and H. Chen *et al.* (2018) positively associate fiscal decentralization with environmental degradation and determine fiscal decentralization decline the environmental quality, thus improving environmental pollution. Similarly, C. He *et al.* (2012), Sigman (2007); J. Liu *et al.* (2017); Que *et al.* (2018); Kuai *et al.* (2019); Esty (1996); Ljungwall and Linde-Rahr (2005); Kunce and Shogren (2008); Taguchi and Murofushi (2010); Batterbury and Fernando (2006); Sigman (2014); Fell and Kaffine (2014) empirically investigated that fiscal decentralization is a major factor for promoting environmental degradation.

There is no consensus in the literature about the association between fiscal decentralization and environmental degradation. K. Zhang et al. (2017) and X. Chen and Chang (2020) have opinioned that the “Race to the Bottom” hypothesis is responsible for a positive association between environmental degradation and fiscal decentralization. On the contrary, Hao et al. (2020), S. Cheng et al. (2020), and K. Li et al. (2020) believe that the “Race to the Top” hypothesis is responsible for the negative association between fiscal decentralization and environmental degradation. As a result, investigating the influence of nonlinear fiscal decentralization on environmental quality is required to develop a strong policy framework (Shan et al., 2021).

2.2. Green Energy and Environmental Degradation

The gradual shift from non-renewable to renewable energy solutions leads to continuous improvement in ecological quality. Ozturk *et al.* (2016); Esso and Keho (2016); Bekhet *et al.* (2017); (Baloch, Zhang, *et al.*, 2019); Charfeddine and Mrabet (2017); Baloch, Zhang, *et al.* (2019); Ozcan *et al.* (2020); and C.-Z. Chen and Lin (2008) empirically investigated a positive relationship between non-renewable energy consumption and ecological footprint as it is the major determinant responsible for increasing environmental footprint. Similarly, B. Chen *et al.* (2007) for China between 1981 and 2001, Caviglia-Harris *et al.* (2009) for selected 146 countries between 1961 and 2000, and Al-Mulali *et al.* (2016) for selected 144 countries in 1988 till 2008 determine that primary energy or non-renewable energy consumption is the major determinant of ecological footprint. Considering the importance of green energy in the arena of ecological footprint, certain studies also investigate the importance of renewable energy consumption to control the burden on ecological footprint. Sarkodie *et al.* (2020); Destek and Sarkodie (2019); Dogan *et al.* (2019); Ozcan *et al.* (2018); Bello *et al.* (2018) and Destek *et al.* (2018) empirically investigated that green energy is a significant determinant to reduce the ecological footprint and thus promote environmental quality. Similarly, Destek and Sinha (2020) for twenty-four OECD countries empirically investigated that increasing green energy reduces pressure on ecological footprint and vice versa. Similarly, Pata (2021) for BRICS countries between time period of 1971 and 2016 determines that renewable energy consumption reduces ecological footprint. Similarly; Usman *et al.* (2020) by using ARDL model for quarterly data from 1985:Q1 to 2014:Q4 determines for USA that renewable energy exerts negative pressure on increase in ecological footprint. On the contrary; Nathaniel *et al.* (2020) for MENA countries in time span of 1990 to 2016 empirically investigated that green energy does not contribute to the environmental quality.

2.3. Economic Policy Uncertainty and Environmental Degradation

Economic Policy Uncertainty may have environmental consequences in addition to its financial products. EPU may compel producers to use inefficient and environmentally damaging production methods, hence increasing CO2 emissions. Furthermore, EPU may impact consumption and investment, resulting in lower CO2 emissions (Anser *et al.*, 2021). Literature such as Pirgaip and Dinçergök (2020); Q. Wang *et al.* (2020); Ulucak and Khan (2020); Yu *et al.* (2021); Anser *et al.* (2021) shows the positive association between environmental degradation and economic policy uncertainty and determine that economic policy uncertainty is major and positive determinant environmental degradation. Similarly, Jiang *et al.* (2019) investigated that economic policy uncertainty in the USA is an economic problem that diverts Government attention from environmental burning concerns and thus causes indirect degradation to the environment and reduces environmental quality. In addition Adams *et al.* (2020) by replacing Economic Policy Uncertainty with World Uncertainty Index as a proxy of uncertainty empirically investigated that it is the major determinant responsible to escalate environment deterioration and CO_2 emission. On the other hand, Adedoyin and Zakari (2020) depicts that economic policy uncertainty increases environmental quality in the short run and then ultimately ecological degradation in the long run.

3. Research Methodology

3.1. The Model

The paper aims to empirically investigate the asymmetric imoact of fiscal decentralization on ecological footprint. We exhibit the ecological footprint as a function of fiscal decentralization, green energy, and economic policy uncertainty as given below:

$$EFP = f(FED, GE, EPU) \tag{1}$$

Where EFP is ecological footprint, FED is fiscal expenditure decentralization, GE is green or renewable energy, and EPU is economic policy uncertainty. Then we convert this function into a regression equation shown as equation 2, which determines the mathematical relationship between dependent and presumed determinants to check their relationship.

Mathematically:

$$EFP_t = \alpha_0 + \alpha_1 FED_t + \alpha_2 GE_t + \alpha_3 EPU_t + e_t \quad (2)$$

Where t shows each quarter of the selected data as subscripts and α_0 … α_3 are respective parameter coefficients. The dependent variable is anticipated to respond to both increases and decreases of each independent variable in the traditional cointegration (Badeeb & Lean, 2018). Linear Unrestricted Error Correction Model (UECM) without asymmetry or nonlinear impact, both in the long run and short run, is shown in Equation 3 with α_i and β_i as short run and long-run parameters, respectively. On the other hand, e_t shows the residual term with mean is equal to zero and constant variance.

$$\begin{aligned}\Delta EFP_t = \alpha_0 + \sum_{k=1}^{m} \alpha_1 \Delta EFP_{t-k} + \sum_{k=0}^{m} \alpha_2 \Delta FED_{t-k} + \sum_{k=0}^{m} \alpha_3 \Delta GE_{t-k} + \sum_{k=0}^{m} \alpha_4 \Delta EPU_{t-k} + \\ \beta_1 FED_{t-1} + \beta_2 GE_{t-1} + \beta_3 EPU_{t-1} + e_t\end{aligned} \quad (3)$$

3.2. The Methodology

The rapid response of ecological footprint concerning fluctuations in fiscal expenditure decentralization in selected OECD countries could be a hint of asymmetric relationship in the short term, while fluctuation may cause consistent impact in the long run. Following Shin *et al.* (2014) through asymmetric modification in linear long-run and short-run empirical analysis, FED_t is decomposed into partial sum of two new time series variables of each of the variable. As it is noted that there is a contradiction about the role of fiscal decentralization in improving environmental quality and sustainability, particularly as “Race to the Top” hypothesis and “Race to the Bottom” hypothesis; there is an asymmetric association between environment and fiscal decentralization (Li *et al.*, 2021). More specifically, one determines the partial sum of positive changes in FED that is FED_t^+ and another one is FED_t^- as partial sum of negative fluctuations in Fiscal Expenditure Decentralization. The specification is given below in Equations 4 and 5.

$$FED_t^+ = \sum_{m=1}^{t} \Delta FED_t^+ = \sum_{m=1}^{t} \max(FED_t^+, 0) \quad (4)$$

$$FED_t^- = \sum_{m=1}^{t} \Delta FED_t^- = \sum_{m=1}^{t} \max(FED_t^-, 0) \quad (5)$$

Equation 6 shows the Asymmetric Error Correction Model (AECM), which inserts partial sum of positive and negative fluctuations of fiscal expenditure decentralization as FED_t^+ and FED_t^- to determine the long-run and short-run asymmetric or nonlinear impact of fiscal decentralization of expenditures on the ecological footprint in selected OECD countries.

$$\Delta EFP_t = \alpha_0 + \sum_{k=1}^{m} \alpha_1 \Delta EFP_{t-k} + \sum_{k=0}^{m} (\alpha_2^+ \Delta FED_{t-k}^+ + \alpha_2^- \Delta FED_{t-k}^-) + \sum_{k=0}^{m} \alpha_3 \Delta GE_{t-k} + \sum_{k=0}^{m} \alpha_4 \Delta EPU_{t-k} + \beta_1 EFP_{t-1} + \beta_2^+ FED_{t-1}^+ + \beta_2^- FED_{t-1}^- + \beta_3 GE_{t-1} + \beta_4 EPU_{t-1} + e_t \quad (6)$$

Wald test can be used to test the long-run symmetry in the model (Badeeb & Lean, 2018; Li *et al.*, 2021) where the null hypothesis is $\beta_2^+ = \beta_2^-$. The short-run positive and negative fluctuations or shocks in FED are shown by the coefficient $\alpha_2^+ and \alpha_2^-$, respectively. The Wald test can also be used to determine the short-run asymmetric impact with the null hypothesis of $\alpha_2^+ = \alpha_2^-$ (Atil *et al.*, 2014; Badeeb & Lean, 2018; Li *et al.*, 2021).

It is important to note that Equation no 3 interprets linear short-run and long-run determinants of ecological footprint (ARDL model) while Equation no 6 determines asymmetric or nonlinear short-run and long-run determinants of ecological footprint in selected five OECD countries. It determines NARDL (nonlinear ARDL) as it includes the model's short-run and long-run partial sum of positive and negative fluctuations.

Finally, appropriate diagnostic tests are used to determine the reliability, stability, and predictability of NARDL coefficients of the model. The Breusch -Godfrey LM test (Breusch, 1978; Godfrey, 1978) was used to verify the residuals auto-correlation and serial correlation. Ramsey's RESET test (Ramsey, 1969) was used to verify the normal distribution of the residual terms and the appropriate functional form of the model. Auto-correlation and ARCH, i.e., Autoregressive Conditional Heteroscedasticity (Engle, 1982), is used to check the residuals.

3.3. Data Description

Annual time series data for the variables of this study has been taken from 1998 to 2017 and is converted to quarterly time-series data by using the quadratic match sum method. The quadratic match sum method for converting the data from low frequency to high frequency is a good technique to reduce variations in the data and thus solves the problems related to seasonal variations (M. Cheng *et al.*, 2012; Faisal *et al.*, 2018; Türsoy & Faisal, 2018); moreover, it also enhances the long-run relationship investigation between exogenous variables and dependent variable (Kisswani *et al.*, 2020). A time series quarterly data has been taken from 1998 quarter one to 2017 quarter four. All variables are subjected to the natural logarithm. Total three exogenous variables are examined to explore their impact on ecological footprint, which are further explained in Table. 1

Table 1: Description of variables

Variables	Description	Source
EP	Ecological Footprint in million gha	Global Footprint Network
FED	The ratio of own spending to general government expenditures	International Monetary Funds
GE	Renewable energy consumption % of total final energy consumption	WDI 2020
EPU	Quarter-wise arithmetic mean of EPU_M where $EPU_M = \frac{3CGPU_{3c-2} + 2CGPU_{3c-1} + CGPU_{3c}}{6}$ CGPU = Monthly Economic Policy Uncertainty where C shows Cyclical.	Economic Policy Uncertainty Index www.policyuncertainty.com

Fiscal expenditure decentralization is an important measure to determine the political risk (Su *et al.*, 2021), which is a ratio of provincial expenditures to general government expenditure (Su *et al.*, 2021; K.-H. Wang *et al.*, 2021). However, the environmental impact of political decentralization has remained an important factor (Hao *et al.*, 2020) where local and provincial governments are given the authority to control the economic activities in the allocated area (Farzanegan & Mennel, 2012; Hao *et al.*, 2020; L. Liu *et al.*, 2019). Renewable energy collected from renewable energy resources such as wind, waves, geothermal, solar, heat, and rain is also called green energy. Green energy is environment friendly and has significant economic benefits, energy security, and reducing climate change (Zandi & Haseeb, 2019). Green energy consumption as a percentage of total final energy consumption is another exogenous variable of this study to determine the impact on the ecological footprint in selected OECD countries. Economic policy uncertainty is unpredictably linked with regulatory authorities, fiscal and monetary policies, which can affect economic short-run and long targets and also has sustainable environmental consequences (Adedoyin & Zakari, 2020). The economic policy uncertainty in this research paper is news based economic policy uncertainty. Baker *et al.* (2016) developed news based economic policy uncertainty by calculating the proportion of news articles showing policy uncertainty about fiscal and monetary policies, health care facilities, laws and order situation, trade policy, debt, and currency uncertainty (Azqueta-Gavaldón, 2017). These measures concern newspaper credibility, impartiality, biasness, and consistency when measuring policy uncertainty (Amin & Dogan, 2021).

4. Model Estimation and Result Analysis

4.1. Unit Root

The pre-requisite to using NARDL to investigate the asymmetric impact of exogenous variables on ecological footprint is to test the time series data for stationarity. It is important to note that NARDL models are employed after checking whether all the variables are stationarity at level or first difference or the mixture of I(0) and I(1). However; if any independent variable is found stationary at the second difference I(2) or higher difference order; the NARDL is not an appropriate choice to empirically investigate the asymmetric relationship between exogenous and dependent variables of the model; in other words, it will give spurious results (Badeeb *et al.*, 2021; Ibrahim, 2015). In this study, Clemente *et al.* (1998) structural break unit root is used to check the unit root in the data with one structural breakpoint. The test follows two models: an additive outlier (AO) and an Innovative Outlier (IO). The first model, the addictive outlier model, covers abrupt changes or fluctuations. In contrast, the second one covers the gradual or incremental changes in the mean of the variables in the model. In this case, the AO model prefers to judge the stationary decision because of sudden or abrupt structural changes rather than gradual or show fluctuations. Table 2 shows the outcomes of Clemente *et al.* (1998) unit root test and determines that none of the variables is stationary at the second difference, which satisfies the pre-requisite condition to use the NARDL model for further analysis.

Table 2: Results of Unit root test with one structural break

Australia

Variables	Innovative Outlier				Additive Outlier			
	Level		1st Difference		Level		1st Difference	
	t-Stats	TB	t-Stats	TB	t-Stats	TB	t-Stats	TB
EP	-3.63	2011Q1	-5.74*	2016Q3	-3.81	2010Q3	-7.51*	2016Q3
FED	-6.36*	2003Q4	--	--	-12.23*	2003Q2	--	--
GE	-4.92**	2002Q1	--	--	-4.48	2001Q3	-5.76*	2015Q2
EPU	-5.49*	2007Q4	--	--	-5.60*	2007Q4	--	--
				Canada				
Variables	Innovative Outlier				Additive Outlier			
	Level		1st Difference		Level		1st Difference	
	t-Stats	TB	t-Stats	TB	t-Stats	TB	t-Stats	TB
EFP	-4.94**	2002Q4	--	--	-4.7***	2002Q2	--	--
FED	-2.73	2014Q4	-9.28*	2014Q1	-3.07	2014Q4	-9.20*	2015Q3
GE	-5.57*	2015Q1	--	--	-5.76*	2014Q3	--	--
EPU	-4.95**	2008Q3	--	--	-5.0**	2008Q2	--	--
				Germany				
Variables	Innovative Outlier				Additive Outlier			
	Level		1st Difference		Level		1st Difference	
	t-Stats	TB	t-Stats	TB	t-Stats	TB	t-Stats	TB
EFP	-7.1*	2005Q4	--	--	-6.7*	2005Q4	--	--
FED	-4.43	2012Q2	-6.85*	2010Q1	-4.58	2012Q2	-6.70*	2016Q3
GE	-4.43	2000Q2	-8.21*	2017Q2	-4.54	2000Q2	-8.37*	2017Q1
EPU	-6.56*	2003Q1	--	--	-6.66*	2003Q2	--	--
				UK				
Variables	Innovative Outlier				Additive Outlier			
	Level		1st Difference		Level		1st Difference	
	t-Stats	TB	t-Stats	TB	t-Stats	TB	t-Stats	TB
EFP	-3.65	2009Q1	-6.80*	2001Q1	-3.51	2008Q3	-6.68*	2011Q1
FED	3.67	2009Q1	-8.79*	2000Q1	-3.48	2001Q2	-8.44*	1999Q2
GE	-5.22**	2012Q1	--	--	-4.8***	2011Q3	--	--
EPU	-5.31**	2016Q1	--	--	-5.22	2015Q4	--	--
				USA				
Variables	Innovative Outlier				Additive Outlier			
	Level		1st Difference		Level		1st Difference	
	t-Stats	TB	t-Stats	TB	t-Stats	TB	t-Stats	TB
EFP	-4.50	2010Q2	-7.16*	2009Q1	-4.21	2010Q2	-7.74*	2008Q2
FED	-3.67	2009Q1	-8.79*	2000Q1	-3.48	2001Q2	-8.44*	1999Q2
GE	-4.53	1999Q1	-8.56*	2001Q1	-3.80	1998Q4	-8.11	2001Q1
EPU	-5.0**	2003Q2	--	--	-5.15**	2003Q2	--	--

*, **, *** denotes 1%, 5% and 10% level of significance.

4.2. Wald Test and Model Selection Criteria

It is important to note that the choice of lag order is receptive to selecting the optimal lag length for the NARDL model. There are different selection measures used to determine the most suitable lag length. Due to the limited number of observations, lag length can be imposed to an appropriate, limited number (Badeeb et al., 2020). Here we assess three lags of each of the first differences of the variables. The Wald test is used to judge the presence of the long-run and short-run symmetric and asymmetric relationship between an exogenous variable and ecological footprint (Badeeb & Lean, 2018; Jafri et al., 2021; Li et al., 2021). Table 3 exhibits long-run asymmetric relationship in Australia and USA, short-run asymmetric relationship in Canada and Germany, and symmetric relationship in the UK both in the long run and short run between fiscal expenditure decentralization and ecological footprint for the respective countries.

Table 3: Wald Test for Short Run and Long Run Symmetry

	Long Run W_{LR}	Short Run W_{SR}	Selected Specification
Australia	4.356**	1.154	NARDL with LR Asymmetry
	(0.04)	(0.287)	
Canada	0.05	2.93***	NARDL with SR Asymmetry
	(0.821)	(0.09)	
Germany	0.087	4.3**	NARDL with SR Asymmetry
	(0.786)	(0.04)	
UK	1.81	0.20	Symmetry (ARDL)
	(0.18)	(0.75)	
USA	3.87**	0.0006	NARDL with LR Asymmetry
	(0.05)	(0.97)	

*, **, ***1% 5% 10% level of significance. Probability values are in parenthesis

4.3. Main Results and Discussion

4.3.1 Empirical Results

As indicated in Table 4, the analysis empirically discusses these countries' long and short-run dynamics one by one.

4.3.1.1 Australia

Wald test supports a long-run asymmetric and short-run symmetric relationship by depicting the long-run positive relationship between the partial sum of positive changes in fiscal expenditure decentralization and ecological footprint. At the same time, the partial sum of negative changes is not a substantial determinant of ecological footprint in the long run. At the same time, green energy is the negative determinant of an ecological footprint both in the long and short run. Contrary, the economic policy uncertainty is not a substantial determinant of ecological footprint in both periods. Jiang *et al.* (2019) also empirically concluded that EPU is not the major determinant of carbon emission in the commercial sector.

4.3.1.2 Canada

The result depicts a short-run, negative, but significant relationship between the partial sum of positive changes in fiscal expenditure decentralization and ecological footprint in Canada. Contrary, there is a long-run positive and symmetric relationship between these two variables. Unlike Australia, in this country, green energy is neither a significant factor of ecological footprint in the long run nor in the short run. Likewise, economic policy uncertainty is not a substantial factor in an ecological footprint both in the long and short run.

4.3.1.3 Germany

Table. 4 suggests that the partial sum of adverse changes in fiscal expenditure decentralization is the positive short-run determinant of an ecological footprint as the Wald test determines the short-run asymmetry between them. Likewise, fiscal expenditure decentralization has a negative but symmetric relationship with the ecological footprint in the long run. On the other hand, green energy is only a long-run negative determinant that suggests replacing green energy with non-renewable energy in the long run to reduce environmental pressure in the country. Moreover, economic policy uncertainty is a negative but significant factor of an ecological footprint both in the long and short run.

4.3.1.4 United Kingdom

As per the Wald test and ARDL model, a symmetric, significant and positive relationship is found between fiscal expenditure decentralization and ecological footprint in the long and short run. Contrary, green energy is neither a significant variable of ecological footprint in the long run nor the short run. On the other hand, economic policy uncertainty is a negative but significant determinant of ecological footprint in the long run only.

4.3.1.5 United States of America

Like Australia, the Wald test confirms long-run asymmetry between fiscal expenditure decentralization and ecological footprint in the USA. Positive changes in expenditure decentralization are positive long-term determinants of ecological footprint; contrary, with no influence in the short run. Moreover, green energy is the negative determinant of ecological footprint in the short-run and the long-run. Therefore, in the United States of America increase in green energy for production and consumption purpose is suggested to reduce the ecological pressure. While economic policy uncertainty is a negative but significant determinant of an ecological footprint both in the long and short run. While economic policy uncertainty is a negative but significant factor or determinant of an ecological footprint both in the long and short run.

Table 4: Nonlinear ARDL estimation results

Australia		Canada		Germany	
NARDL with LR Asymmetry		NARDL with SR Asymmetry		NARDL with SR Asymmetry	
0’l;	3.66** (2.04)	FED_{t-1}	0.83*** (1.80)	FED_{t-1}	-3.96** (-2.14)
FED^{-}_{t-1}	2.92 (1.9)	--		--	--
GE_t	-0.033* (-2.52)	GE_{t-1}	-0.0008 (-0.05)	GE_{t-1}	0.0003 (0.07)
EPU_t	-0.0035 (-0.78)	EPU_{t-1}	-0.006 (-1.26)	EPU_{t-1}	-0.013* (-2.76)
ΔFED_t	-2.55 (-0.80)	ΔFED^{+}_t	-18.05* (2.85)	ΔFED^{+}	-1.61 (0.32)
ΔFED_{t-1}	2.60 (0.63)	--	--	ΔFED^{+}_{t-1}	3.18 (0.69)
		ΔFED^{-}_t	8.52 (0.81)	ΔFED^{-}	9.21 (1.50)
		ΔFED^{-}_{t-1}	5.47 (0.5)	ΔFED^{-}_{t-1}	16.13** (2.24)
ΔGE_t	-0.11** (-2.34)	ΔGE_t	-0.034 -0.81	ΔGE	-0.09* (-3.73)

		ΔGE_{t-1}	0.04 (0.041)	-- --	-- --
ΔEPU_t	0.0004 (0.08)	ΔEPU	-0.004 (-0.62)	ΔEPU	-0.0084** (-1.95)
		--	--	--	--
Constant	1.78* (2.87)	Constant	3.04* (3.57)		5.9* (5.27)
Long Run Coefficient					
$LFED^{+}$	35.56***	LFED	4.95*	LFED	-12.46**
$LFED^{-}$	-28.57	--			
United Kingdom				USA	
Symmetric ARDL				NARDL with LR Asymmetry	
FED_{t-1}	1.82*** (1.73)			FED^{+}_{t-1}	1.53*** (1.70)
				FED^{-}_{t-1}	-0.44 (-0.76)
GE_{t-1}	0.0023 (0.46)			GE_{t-1}	-0.038* (-3.18)
EPU_{t-1}	-0.0067** (-2.26)			EPU_{t-1}	-0.021* (-3.97)
ΔFED	7.04* (2.81)			ΔFED	-4.12 (-1.56)
--	--			ΔFED_{t-1}	0.37 (1.54)
ΔGE	-0.03 (-0.64)			ΔGE_t	-0.089* (-2.40)
ΔGE_{t-1}	0.04 (0.82)			--	--
ΔEPU	-0.003 (-0.96)			ΔEPU_t	-0.009** (-2.02)
Constant	1.51* (3.10)			Constant	4.3 (4.86)
LFED	1.82**			$LFED^{+}$	7.25**
				$LFED^{-}$	2.09

*, **, ***1% 5% 10% level of significance, t-statistics are in parenthesis. Long run co-efficient effect (- and +) refers to permanent change in exogenous variables by (-1 and +1) respectively

4.3.2 Discussion

4.3.2.1 Fiscal Decentralization and Environmental Degradation

A partial sum of positive changes in expenditure decentralization increases the ecological footprint in Australia and USA in the long run. These results are also in-line with Li *et al.* (2021) at a 5% level of significance used as an environmental proxy. Li *et al.* (2021) suggested that in the long-run positive changes of fiscal expenditure decentralization have a positive association with environmental degradation for Pakistan between 1984 and 2018. On the contrary, Yan and Zhong (2012) and K. Zhang et al. (2017) argued that fiscal decentralization could not help control emissions. You *et al.* (2019) suggested that “Race to Bottom” is the major reason for a positive relationship between fiscal expenditure decentralization and environmental footprint in the long run. Most high-profit enterprises are attracted by decentralized governments that do not impose strong environmental regulations, leading to “Race to Bottom”(You *et al.*, 2019).

On the other hand, Du and Sun (2021) regarded capital competition and biased and partial technological development as a major cause of a nonlinear but positive association between fiscal decentralization and environmental degradation. However, the negative changes in expenditure decentralization are not a significant variable of ecological footprint but also positively associated with an ecological footprint in both countries in the long run. Likewise, Q. He (2015) and Li *et al.* (2021) investigated the positive but insignificant relationship between fiscal expenditure decentralization and environmental degradation in the long run.

As Table 3 suggests, the symmetric long-run relationship between fiscal expenditure decentralization and ecological footprint in Canada, Germany, and United Kingdom. In Canada and the United Kingdom, fiscal expenditure decentralization is positively interlinked with an ecological footprint in the long run. These results are also in line with previous literature such as L. Liu and Li (2019), You *et al.* (2019), Du and Sun (2021), Li *et al.* (2021); Shan *et al.* (2021) and Y. Cheng *et al.* (2021) as these studies show a positive relationship between fiscal decentralization and environmental degradation in the long run. Shan *et al.* (2021) confirm the typical inverted U-shaped relationship between environmental degradation and fiscal decentralization for seven selected OECD countries. The potential reason is local or decentralized governments, while keeping GDP growth in mind, attract relatively cheaper and easily accessible resources for production function to stimulate higher profit industries but on the expenses of environment sustainability. Therefore this “Race to Bottom Hypothesis” is the major cause of positive relationship between environmental degradation and fiscal expenditure decentralization.

The short-run analysis depicts quite interesting output, as shown in Table 4. In Germany, the short-run asymmetric relationship between fiscal expenditure decentralization and ecological footprint is in line with S. Cheng et al. (2020), who determines the nonlinear relationship between fiscal expenditure decentralization and environmental degradation in China. According to S. Cheng *et al.* (2020) increase in per capita fiscal expenditure decentralization will reduce CO_2 emissions in China. Contrary, Li *et al.* (2021) exert a positive short-run relationship between fiscal expenditure decentralization and ecological footprint in Pakistan. It is interesting to note Shan *et al.* (2021) depicts both positive and negative short-run relationship between environmental degradation proxy that is CO_2 emission and fiscal decentralization in different provinces of China. The research has concluded that the sign of relation coefficient between environment and fiscal decentralization depends on technological progress and energy consumption methods. Therefore fiscal decentralization coupled with technological progress can reduce carbon emission (Shan *et al.*, 2021).

Table 4. shows both short-run and long-run symmetric, significant, and positive relationships between fiscal expenditure decentralization and ecological footprint in the United Kingdom. These results are supported by previous literature. According to L. Liu and Li (2019), the possible explanation is as fiscal decentralization (expenditure decentralization) increases, local governments seeking to maximize their benefits choose to focus on the development of the local economy than improving environmental quality. Such a strategy intensifies pollution in the environment. CO2 emissions also have a significant negative externality; conversely, de-carbonization has a significant positive externality. Local governments are interested in free rides to maximize regional economic growth, resulting in a steady increase in carbon emissions. Yang *et al.* (2020) also investigated the same positive correlation between fiscal expenditure decentralization and environmental degradation for China. It is suggested that local governments avoid the “Free Riding” of resources to boost economic output on the expenses of environmental sustainability. Similarly, L. Liu *et al.* (2019) and Hao *et al.* (2020) empirically supported these results. They investigated the positive relationship between fiscal decentralization and

environmental footprint or environmental degradation at the first stage, empirically proving an inverted U shape relationship between them. These studies have concluded that there is "Race to Bottom Hypothesis" prevailing, which is responsible for deteriorating environmental sustainability at local level.

Result suggests fiscal expenditure decentralization is not the major or significant determinant of ecological footprint in the short run in Australia and the United States of America. These results are also in-line with S. Cheng *et al.* (2020), who didn't find any significant relationship between fiscal expenditure decentralization and environmental degradation in China between 1995 and 2010. To better comprehend Table. 5 has summarized these results.

Table: 5. Result Summary (Fiscal Expenditure Decentralization and Ecological Footprint)

FED Impact		Australia	Canada	Germany	UK	USA
Long Run	Increase in FED	+	{+}	{-}	{+}	+
	Decrease in FED	NS				NS
Short Run	Increase in FED	{NS}	-	NS	{+}	{-}
	Decrease in FED		NS	+		

NS represents not Significant, { } shows symmetric, + and – shows positive and negative relationship respectively.

4.3.2.2 Green Energy and Environmental Degradation

Table. 4 shows renewable energy consumption is a major determinant of ecological footprint in Australia and the United States of America both in the short run and long run. The result also determines the long-run and short-run negative relationship between green energy consumption and ecological footprint in both countries. On the other hand, in the United Kingdom and Canada, green energy consumption is not a major determinant of an ecological footprint both in the short-run and long-run and draws no significant influence on ecological footprint. On the contrary, green energy is a negative determinant of ecological footprint in Germany in the short run but not a significant variable in the long run. Energy-incentive inputs can increase growth, sustainability, and quality (Majeed & Tauqir, 2020; Zhao *et al.*, 2013). However, non-renewable energy resources deteriorate environmental quality and sustainability (Baloch, 2018; Baloch & Suad, 2018; Baz *et al.*, 2020; Majeed & Luni, 2019; Munir & Riaz, 2020; Pao & Tsai, 2010, 2011). Similarly, S. Wang *et al.* (2011) ; Saboori and Sulaiman (2013); Shahbaz *et al.* (2012); Ozturk and Acaravci (2013); Ahmad *et al.* (2016); (Bekhet *et al.*, 2017; Esso & Keho, 2016); Ozturk *et al.* (2016); Solarin *et al.* (2017); Mrabet and Alsamara (2017); Atasoy (2017); B.

Zhang *et al.* (2017); Alvarado *et al.* (2018); S. Chen *et al.* (2019); Sohail *et al.* (2021); Majeed and Tauqir (2020); also investigated the positive relationship between of non-renewable energy consumption and environmental degradation, on the contrary, the use of renewable energy resources or green energy has reduced environmental pollution and thus decreased CO_2 emission to a certain extend (Majeed & Luni, 2019; Ozturk *et al.*, 2016; Z. Wang *et al.*, 2018; Zhang *et al.*, 2018). Along with these findings Charfeddine (2017), Baloch, Zhang, *et al.* (2019); (Ozcan *et al.*, 2020), Majeed *et al.* (2021), and Charfeddine and Mrabet (2017) has explored non-renewable that an increase in non-renewable energy resource exploitation increases the extent of ecological footprint. On the contrary, Sarkodie *et al.* (2020); Alola *et al.* (2019); Baloch, Mahmood, *et al.* (2019); Dogan and Seker (2016); Dogan and Ozturk (2017); Zaidi *et al.* (2018); Khan *et al.* (2020); Vural-Yavaş (2021) ; Swain and Karimu (2020); Chu and Le (2021); Amin and Dogan (2021); Z. Wang *et al.* (2020); Adams and Acheampong (2019) and Chu and Le (2021) found the solution for this problem and empirically investigated that the use of renewable energy helps to not only control and alleviates CO_2 emission but also reduce ecological footprint.

4.3.2.2 Economic Policy Uncertainty and Environmental Degradation

In the long run, in the case of Germany, the UK, and the United States of America, economic policy uncertainty is a negative but significant factor or determinant of ecological footprint, while in the short run, it is significant in Germany and USA only. These results also align with Chu and Le (2021) and Adedoyin and Zakari (2020), who empirically investigated the negative relationship between economic policy uncertainty and environmental degradation. This negative relationship is if EPU draws an effect on volume and pattern of consumption that will surely reduce CO_2 emission and ultimately environmental degradation and ecological footprint. To compensate for the low revenue induced by EPU, manufacturers utilize low-cost energy sources in their production methods. As a result, when revenue grows, they use environmentally friendly production methods in such industries, resulting in lower CO2 emissions (Amin & Dogan, 2021). Similarly, Syed and Bouri (2021) exhibit that EPU increases CO2 emissions in the short run, implying that high EPU is responsible for short-term environmental damage. However, EPU reduces CO2 emissions in the long run, interpreting that a high EPU improves environmental quality. Given the evidence of a trade-off between EPU and CO2 emissions, authorities should take immediate steps to minimize EPU to improve environmental quality. In the long run, if policymakers want to limit EPU and CO2 emissions simultaneously, they should look for alternative strategies to offset CO2 emissions (for example, renewable energy consumption). Contrary, Amin and Dogan (2021); Pirgaip and Dinçergök (2020); Adams *et al.* (2020) ; Q. Wang *et al.* (2020); Ulucak and Khan (2020); Yu *et al.* (2021); Anser *et al.* (2021); Zakari *et al.* (2021); Adedoyin *et al.* (2021) empirically investigated that economic policy uncertainty adversely influences the environmental quality and enhance environmental degradation by escalating CO_2 emission. The current study further shows that there is a negative relationship between economic policy uncertainty and ecological footprint both in Germany and the USA. While in the case of Australia and Canada, economic policy uncertainty is not the major determinant of ecological footprint both in the short-run and long-run. Jiang *et al.* (2019) also empirically concluded that in commercial sector EPU is not the major determinant of CO_2 emission.

4.4. Diagnostic Tests

Finally, different diagnostic tests are applied to confirm whether the coefficients of the selected nonlinear ARDL model are reliable, stable, and predictable or not. The results of the Breusch-Godfrey LM test (Breusch, 1978; Godfrey, 1978) confirmed that the specified nonlinear ARDL model is free from serial correlation problems, as the probability value of $\mathcal{X}^2$statistical is insignificant at the significance level of 5%. The results of the Ramsey's RESET test (Ramsey, 1969) verified the normal distribution of the residual terms, as the probability value of $\mathcal{X}^2$statistical is insignificant at the significance level of 5%. Similarly, the ARCH test suggests that the selected data for all five OECD selected countries are homoscedastic and no evidence of heteroscedaticity is found at 5% level of significance. Findings of diagnostic tests are given in Table 6.

Table 6. Findings of Diagnostic Tests

	Australia		Canada		Germany		UK		USA	
Test	Stats	Prob	Stats	Prob	Stats	Prob	Stats	Prob	Stats	Prob
Breusch-Pagan-Godfrey LM	0.32	0.72*	0.21	0.81*	0.02	0.89*	0.92	0.40*	0.81	0.44*
Ramsey's RESET test	2.88	0.12*	0.023	0.98*	1.24	0.21*	1.0	0.31*	2.50	0.18*
ARCH Test	0.15	0.92*	0.35	0.55*	0.09	0.75*	0.36	0.54*	0.12	0.73*

*5% level of significance

4.5. Cumulative Effects of Fiscal Decentralization, Green Energy and Economic Policy Uncertainty on Ecological Footprint.

The graphical presentation is given in Fig. 2, Fig. 3, Fig. 4, Fig. 5, and Fig. 6 shows the cumulative effect of fiscal decentralization, green energy, and economic policy uncertainty on ecological footprint for Australia, Canada, Germany, UK, and the USA, respectively by determining the positive changes, negative changes and asymmetry in the data.

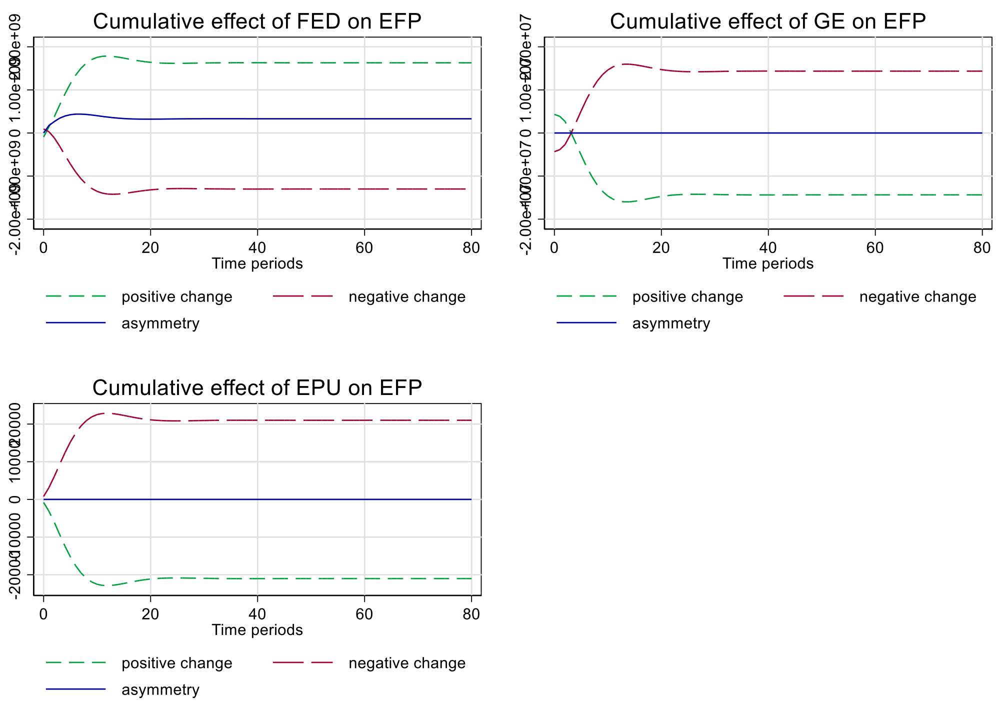

Fig. 2. Cumulative Effects of FED, GE, and EPU on EF for Australia

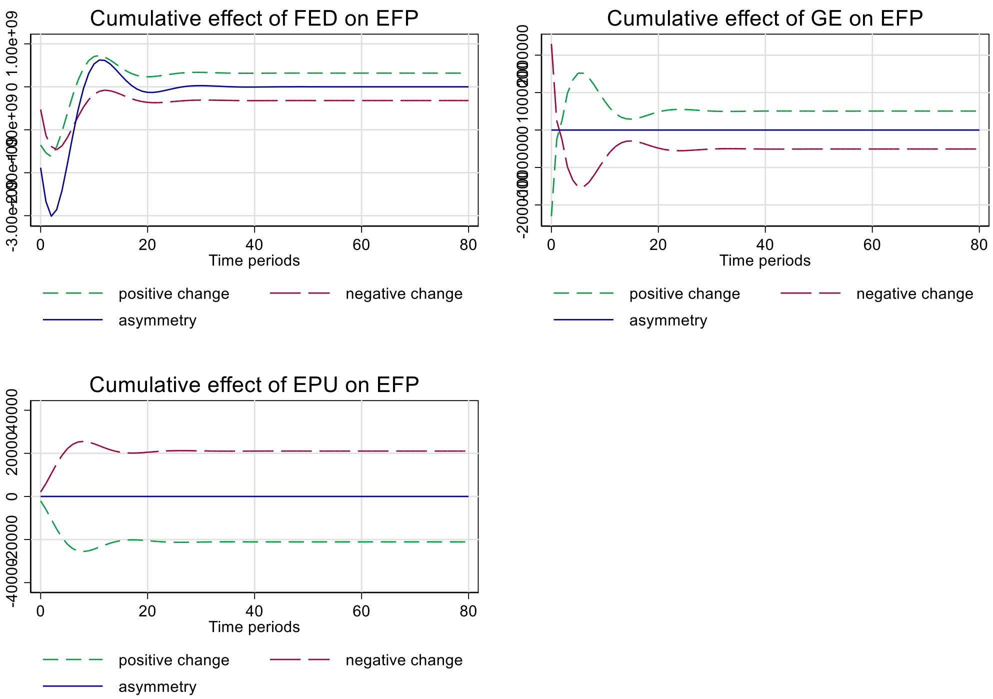

Fig. 3. Cumulative Effects of FED, GE, and EPU on EF for Canada

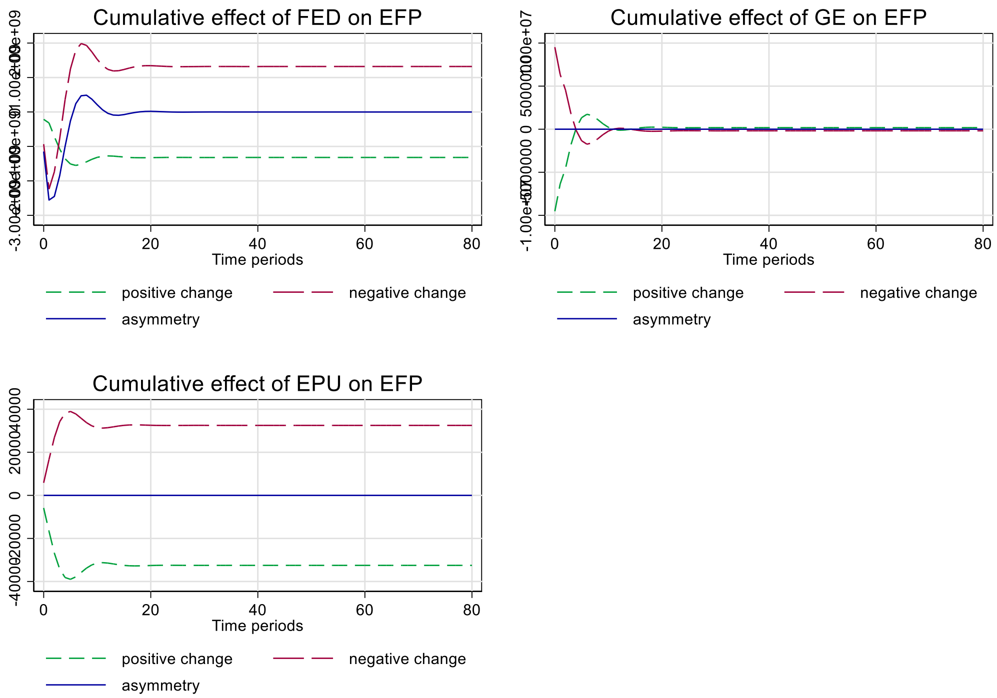

Fig. 4. Cumulative Effects of FED, GE, and EPU on EF for Germany

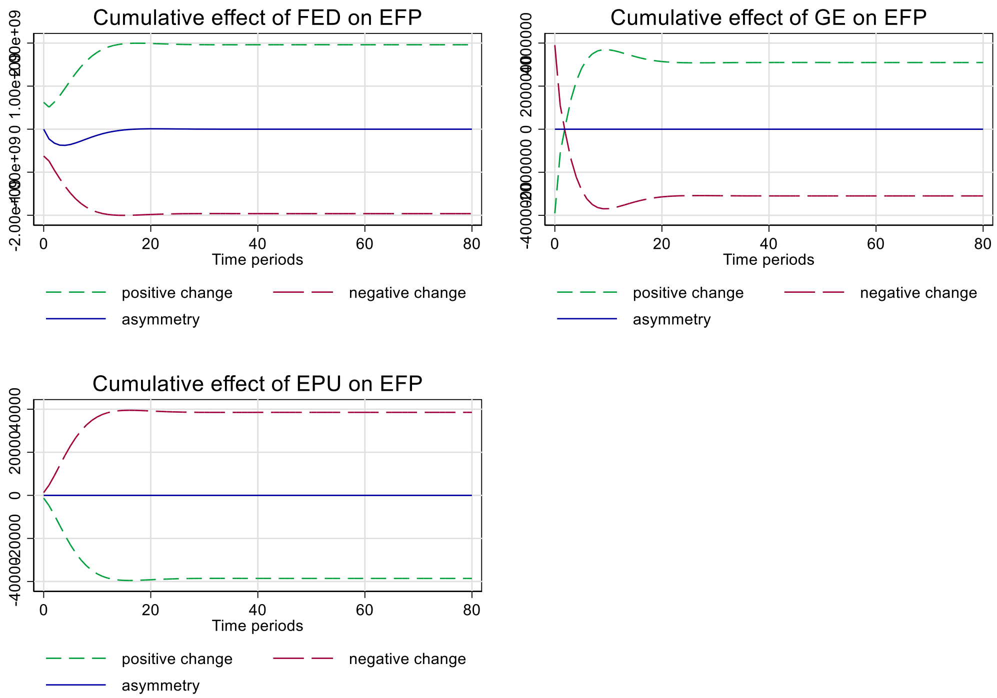

Fig. 5. Cumulative Effects of FED, GE, and EPU on EF for the United Kingdom

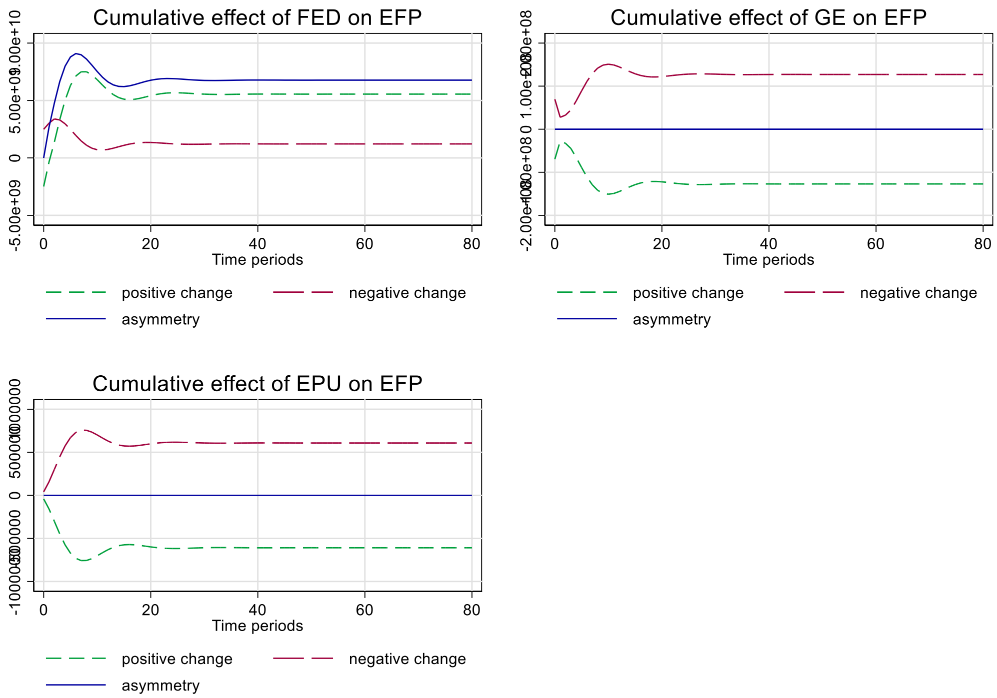

Fig. 6. Cumulative Effects of FED, GE and EPU on EF for the United States of America

5. Conclusion and Policy Implications

The main objective of this study is to empirically investigate the asymmetric or nonlinear relationship between fiscal expenditure decentralization and ecological footprint as a proxy of environmental sustainability both in the short-run and long-run in five selected OECD countries, namely, Australia, Canada, Germany, United Kingdom and the United States of America. This study also explains the empirical symmetric relationship between green energy, economic policy uncertainty, and ecological footprint for these five OECD countries. The results show that fiscal decentralization is asymmetrically correlated with an ecological footprint in the long run only in the case of the USA and Australia, while in the short run, in both of these countries, these variables are symmetrically associated. Contrary, in the United Kingdom, the asymmetric relationship between fiscal expenditure decentralization and ecological footprint is neither found in the long run nor in the short run. On the other hand, in the case of Canada and Germany, fiscal decentralization is asymmetrically interlinked with an ecological footprint in the short run only, while in the long run, there is a linear relationship between these two variables. Empirical evidence also shows that in the case of Australia and the USA, clean energy is a major determinant of an ecological footprint both in the long run and short run.

On the contrary, in the case of Canada and the United Kingdom, clean or green energy is not the major determinant of an ecological footprint both in the long run and short run. On the other hand, in Germany, green energy is a major determinant of ecological footprint in the short run but not in the long run. Another assumed determinant of ecological footprint is economic policy uncertainty. In Germany and the USA, economic policy uncertainty is a significant determinant of an ecological footprint both in the long and short run. On the contrary, economic policy uncertainty is not a significant variable of ecological footprint in Australia and Canada, both in the long run and short run. While in the UK, it is a major determinant of ecological footprint in the long run only.

Specific policy implications are arising from this research. First, more financial resources should be allocated to control the environmental degradation along with more power delegation to countries institutions to design independent policies in very favor of environmental up-gradation and sustainability. Moreover, Central Governments should allocate more powers to local governments to further strengthen the fiscal expenditure decentralization and enhance the projects for clean energy to control environmental degradation. Along with this, increasing the fiscal expenditures ratio both in current and development spheres to improve environmental quality and thus sustainability is an effective tool to apply (Hao et al., 2020). Thus, is also suggested for the selected OECD countries. Similarly, the “Free Riding” behavior of local governments and the industrial sector, fiscal decentralization, should be curtailed by bounding carbon shares in environmental degradation both in the short-run and long run. Setting special autonomous bodies at local and provincial levels to monitor the institutional qualities to guard environmental concerns can play an influential role in this regard. It is also suggested to implement the carbon tax at the very root of provincial and local authority levels, which will play an effective role like a two-way sword, which will not only surge government revenue thus will prompt fiscal revenue decentralization and control environmental degradation, and upgrade climate sustainability. Similarly, delegating more power to the provincial government to manipulate the policies in favor of paradigm shift from extensive economic growth-oriented models to low environmental degradation developmental models, especially low carbon economic growth models to achieve sustainability concerning environmental perspective, will be favorite.

The subsequent policy implication for these countries is to focus on a paradigm shift related to energy portfolio by accumulating the share of green energy in the total sphere of energy consumption. Similarly, proper planning for technological advancements and enhancements in the power sector to enhance carbon capture and storage is the need of the hour to subdue environmental degradation. Therefore it is indispensable to increase green investment to promote environmental quality. Another suggestion is to devise different credit or green credit mechanisms or systems to allow varying interest rates for industries depending on their parts into environmental degradation and carbon emission. The more polluting industries may offer credit at higher interest rates and vice versa, which will compel industries to innovate green or renewable energy production at their potential level. Likewise, industries with low carbon emissions should be given an incentive in the form of a low tax rate or tax exemptions. In parallel, importers should be given subsidies to import green energy products. These suggestions exhibit the collaboration of three crucial goals of Sustainable Development Goals (SDGs), which are to enhance economic growth (SDG no 8), with considering the problem of environmental degradation and to uplift the ecological quality (SDGs no 13) in addition to providing masses affordable green energy (SDG no 7).

Another vital recommendation to control economic policy uncertainty is implying very fair and transparent economic policies so that government authorities and officials can analyze the economic policy uncertainty transparently and diagnose economic illness and thus treat it properly and timely. At the global level, economic organizations such as World Trade Organization, United Nations Organizations, International Monetary Funds, and World Bank must campaign to shrink economic policy uncertainty both at the global and country-wise level.

Apart from these findings, there are certain limitations. Firstly, future studies may focus on finding the threshold level of fiscal decentralization to optimize economic growth with sustainable environmental goals, which is the very soul of SDGs. Secondly, World Uncertainty Index can be a relatively better proxy for monetary policy uncertainty which can be used in future studies for better policies suggestions. Thirdly, this research study assumes the impact of green energy on ecological footprint; however, energy segregation paves the way for future researchers to dissect the energy consumption role in enhancing ecological footprint with particular reference to fiscal decentralization and economic policy uncertainty. Fourthly, this research study assumes fiscal expenditure decentralization as a proxy to fiscal decentralization. However, future studies can develop an index to aggregate the impact of both dimensions of fiscal decentralization, namely, fiscal revenue decentralization and fiscal expenditure decentralization.

Ethical Approval: Not Applicable

Consent to participate: I am free to contact any of the people involved in the research to seek further clarification and information.

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