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Environmental Tax and Pollution Reduction: Exploring the Role of Energy Consumption in Developing Economies

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Due to rapid industrialization, the use of fossil fuels is rising in the world that enhance pollutants emission and deteriorate environmental quality. How to deal with environmental pollution is the main question of current study. The main purpose of the study was to analyze the effectiveness of environmental tax for pollution reduction by capturing the mediating role of energy consumption in developing countries. Panel data was collected from forty (40) developing countries during the period of 2000 to 2020. The results of seemingly unrelated regression (SURE) describes that imposition of environmental tax reduce energy consumption that in turn improve environmental quality. It supports the intervention of government by the imposition of tax and provision of subsidies in the economy to handle environmental pollution in developing countries.

1. Introduction

Since the Industrial Revolution, the use of machinery has increased in the production process, leading to a higher demand for raw materials. Residuals created by using dirty inputs in production and consumption are put back into the environment and degrade environmental quality (Gyamfi et al., 2021). Because fossil fuels are widely available and reasonably priced, they continue to dominate the world's energy mix. Nevertheless, the combustion of fossil fuels generates significant amounts of particulate matter, sulfur dioxide, carbon dioxide, and nitrogen oxides. These emissions are the main contributors to acid rain, air pollution, global warming, and a host of other environmental problems (Fatima et al, 2020).

Market failures occur when the prices of goods and services do not accurately reflect the total social costs, such as environmental damage, linked to their production or consumption (Borenstein & Bushnell, 2022). Economic actors may not have adequate incentives to reduce the environmental impact or investment in pollution control techniques, leading to overuse of natural resources and environmental degradation (Khanam et al., 2023). Environmental degradation creates negative externalities, leading to a gap between public and private costs of poor environmental quality (Meade, 2024). This requisition seeks an answer to the question, *"How can we bridge the gap between social and private costs to reduce environmental damage"?*

Governments all around the world have responded to these issues by increasingly using market-based policy tools, particularly environmental levies, as a means of lowering pollution (de Mello & Jalles, 2025). Internalizing environmental externalities is the foundation of environmental taxes, such as fuel taxes, carbon taxes, and emission charges (Kotchen, 2025). Significant costs are imposed on society by pollution, but these costs are frequently not covered by the polluters (Mousa, 2022).

By internalizing the value of pollution, the cost of emission generating output increases (Klaassen & Riahi, 2007; Rokhmawati et al., 2023). In the short run, firms reduce output due to higher production costs. Therefore, the cost of goods and services increases and it affects the consumption decisions of the consumers (Kalman, 1968; Mesak et al., 2022). In the long run, the imposition of environmental taxes affects firms' investment decisions, prompting them to make structural changes in their production processes (Bovenberg & Goulder, 1996; Guo et al., 2025). These changes lead to investments in green technologies that replace pollution-emitting inputs. Imposing an environmental tax reduces the use of pollution-augmenting inputs thereby improving environmental quality.

2. Literature Review

There are different channels through which environmental taxation effect environmental quality but energy consumption plays a critical role. Arouri et al. (2012) examined the link between carbon dioxide emissions and consumption of energy for Middle East and North African countries between 1981 and 2005. The findings demonstrate that long-term energy consumption significantly reduces CO_2 emissions. Similarly Chen et al (2018) conducted a study to check the significance of energy consumption for pollution

reduction. The results demonstrate that the increase in the use of fossil fuels enhance emission that reduce environmental quality.

Baumol and Oates (1971) conducted a study to examine the methods that are feasible to control environmental pollution. Environmental pollution acts as a negative externality and implementation of environmental tax act as suitable approach to manage environmental pollution. Kwilinski et al (2019) conducted a study to check the importance of environmental tax for environmental quality. The results of the study revealed that different types of environment related tax have different outcomes. Several factors, including tax design, business characteristics, substitution effects, elasticity considerations, the particulars of the environmental problem, policy interactions, and the analysis's time horizon, can be attributed for the variations in results across different types of environment-related taxes. Therefore, environmental quality improves as the carbon emissions are reduced by the increase in environmental tax.

Onofrei et al. (2017) examined environmental taxes effects on carbon emissions for the period of 19 years from 1994 to 2012. They analyzed the direct and indirect impact of environmental taxes on greenhouse gas emissions, and it links to environmental spending, as employed control variables, were examined. The result depicts that environmental tax has significant and negative impact on greenhouse gas emissions whereas, it further depicts that environmental spending has not significantly affected greenhouse gas emissions. Therefore, environment spending has not the vital effect on greenhouse gas emissions because of inefficient policies, lags in results, economic and technological changes, international factors, behavioral responses, baseline emission levels, and interactions to other policies.

Depren et al. (2023) conducted a study in Nordic countries to examine the impact of environmental tax. They employed quarterly data to highlight the significance of environmental tax for carbon emission on aggregated and disaggregated level. They further employed granger causality methodology and results depict that the impact of environmental tax is different as estimated for different levels of income. He et al. (2019) examined the reduction in pollutant emission due to environmental taxes in Organization for Economic Cooperation and Development (OECD) countries. The results depict that high income countries have better environmental quality because of imposition of high tax to improve the environmental quality.

The results depicted that there is a significant correlation between environmental rules and taxes and a decrease in CO2 emissions. These results are consistent with different economic and regulatory theories, and these theories are in favor of putting limitations on environmentally harmful activity and internalizing the external costs of pollution. The result also depicts that fiscal policy instruments like imposition of taxes are the major tool to change the behavior to get ecologically sustainable results. Furthermore, Sen and Vollebergh (2018) employed cross section data of effective energy tax rates for the OECD countries to assess the impact of carbon tax on the consumption of energy in long-term. These results highlighted that the way through which fiscal policies affect environmental pollution and further explained that environmental tax switch the economy towards environmental sustainability.

Similarly, Vehmas (2005) examined the role of environmental tax for environmental quality in Finland. Environmental taxes would be in line with the nation's commitments to addressing climate change, sustainability objectives, and environmental legislation. The precise tax structure, the degree of industry and public compliance, and the overall regulatory environment would all affect how effective these policies are. The findings revealed that taxing CO_2 emissions reduces energy consumption and in turn improves environmental quality.

By employing tax on fossil fuels reduce the demand of goods that generate pollution. The results also indicate that it may be helpful to adopt trading emissions as an alternative to environmental tax to control pollution. But the findings confirm the hypothesis that environmental tax acts as a suitable tool to control emission. The challenge of whether green taxes have an impact on pollution and use of energy was investigated by Morley (2012). The findings demonstrate that there is no correlation between environmental taxes and energy consumption, however there is a substantial inverse relationship between environmental taxes and pollution for the members of European Union (EU).

This indicates that the numerous exclusions for the economy's energy-intensive sectors have only had little effect on the effectiveness of environmental tax. Evaluating environmental taxes relative to overall taxes has a substantial impact. These results also support those studies that contend that the effects of environmental taxes rely on the composition of other tax levels. The results show that environmental taxes are not having a significant effect on energy consumption, and that pollution is being decreased through the deployment of cleaner technologies.

2.1 Research Gap

The role of environmental taxes in lowering pollution has been the subject of a large body of research, but the majority of these studies concentrate on developed economies with robust institutions and well-established environmental policy frameworks, leaving little knowledge of how these taxes function in developing nations. Furthermore, the majority of earlier studies examine how environmental taxes directly affect environmental quality; nevertheless, the mechanisms by which these taxes affect environmental outcomes have received less attention. Particularly, little is known about the mediating function of energy consumption, a crucial channel in economies that rely significantly on fossil fuels.

The above literature highlighted that most of the studies employed the data on emissions and energy use which is normally handled independently from fiscal environmental tools like taxes. Similarly, the exiting literature is mainly limited to the single country analysis and has methodological constraints. Therefore, there is a need to examine the environmental taxes, energy consumption patterns, and environmental quality into a consistent analytical framework, particularly for the developing countries where the effectiveness of policies is uncertain.

3. Research Methodology

The current study examines the factors that affect environmental quality and the basic equation for environmental quality is as follows:

$$EQ = \frac{R}{P} \quad (1)$$

where EQ represents environmental quality, R depicts the use of clean water and green technologies and represents that an increase in the usage of clean water and green technologies in the production sector improves environmental quality (Li et al, 2023). Similarly, P represents the pollution produced by waste created through economic activity like production of goods and services and it highlighted that higher levels of pollution deteriorate environmental quality (Ali and Puppim, 2018). Furthermore, environmental quality plays a role of negative externality in the production sector and, therefore, it encourages the government intervention through fiscal policy like imposition of taxes on those inputs that create pollution.

The current study mainly focuses on examining the implementation of environmental taxes and its impact on environmental quality. Therefore, the study added environmental tax in the above equation to observe its significance for environmental quality.

$$EQ = \frac{R}{P - T_e} \quad (2)$$

The above equation (2) depicts that imposing an environmental tax (Te) reduces pollution and improves environmental quality as it is inversely related to the EQ. There are different channels through which environmental tax affects environmental wherein the channel of energy consumption is more vital. When an environmental tax is implemented, it raises the prices of dirty inputs used in the production of final output, leading to a decrease in demand (Liu and Ge, 2023). As dirty inputs become more expensive, individuals switch to cleaner fuel energy. In this way because of the two-way effect (price and substitution effect), the use of fossil fuels reduces, and it encourages the utilization of clean fuel in production (Bongers, 2023).

Furthermore, along with the environmental taxes, government expenditures on environmental protection also play a important role in improving environmental quality (Zhang et al, 2017). High expenditure enhances productivity, leading to innovations in environmental technology and ultimately improve environmental quality. The study includes energy consumption in equation 2 to examine the impact of environmental tax and government spending on environmental quality.

$$EQ = \frac{R}{P - \alpha T_e - \gamma EEP + (\delta EC)} \quad (3)$$

where, EQ represents environmental quality, T_e represents environmental tax, and EC represents energy consumption. The purpose of this model is to examine the three determinants that influence environmental quality which are environmental tax, expenditure on environmental protection, and energy consumption. Whereas environmental tax and expenditure on environmental protection help to reduce pollution and enhance environmental quality. While energy consumption increases pollution and degrades environmental quality. Therefore, energy consumption is an endogenous variable through which environmental tax affects environmental quality.

3.1 Empirical Models

Based on the theoretical rationale mentioned above, the proposed objectives were achieved by estimating the following empirical models.

$$EC_{it} = \alpha_0 + \alpha_1 ENVRT_{it} + \alpha_2 EEP_{it} + \alpha_3 Pop_{it} + \alpha_4 ACF_{it} + AE_{it} + \mu_{it} \quad (4)$$

$$PM_{it} = \beta_0 + \beta_1 ENVTR_{it} + \beta_2 EC_{it} + \beta_3 ACF_{it} + \beta_4 FDI_{it} + \mu_{it} \quad (5)$$

Equation (4) and (5) shows the significance of environmental tax (ENVTR) for environmental quality that is captured through particular matters (PM). Energy consumption (EC) acts as an endogenous variable which highlights that environmental tax effect environment quality through the channel of energy consumption. Therefore, first we determined the factors affecting energy consumption in equation (4). Along with environmental tax, expenditures on environmental protection (EEP) also play an important role in the use of energy consumption. Further, population growth (Pop), access to clean fuel energy (ACF) and access to electricity (AE) considered as a control variable that in the energy consumption framework.

However, equation (5) shows the determinants that affect environmental quality (PM). Environmental tax (ENVTR) is the main contributor in the environmental quality. Meanwhile, energy consumption (EC) enhances pollution that changes the environmental quality. Further, access to clean fuel energy (ACF) and foreign direct investment (FDI) demonstrated as a control variable for environmental quality.

With an emphasis on the mediating function of energy use in developing nations, this study uses a quantitative empirical approach to investigate the effects of environmental taxes on environmental quality. Panel data representing 40 developing economies during 2000 to 2020 was used in the analysis. The study uses the Seemingly Unrelated Regression (SUR) technique to capture the interconnectedness of the interactions between environmental taxes, energy usage, and environmental quality.

4. Empirical Results and Discussion

The results of first equation describe the importance of environmental related fiscal policies for energy consumption in developing countries. Government employs environmental tax and expenditures on environmental protection as a fiscal tool to improve environmental quality. The coefficient of ($ENVTR_{it}$) has negative sign which describe that implementation of environmental tax reduces energy demand in selected economies. The results are consistent with neoclassical demand theory which describe that tax on dirty inputs enhance prices of fossil fuels. Higher prices lead to lower demand.

Imposition of environmental tax also changes producer behaviour. Because the pollution act as a negative externality, so government impose tax on dirty inputs. The cost of

production rise that shift the supply curve left. Therefore, the firms produce less with higher cost that reduces energy consumption (Pigou, 1920). The findings of Porter hypothesis also confirm the negative effect of environmental tax on pollution. After the imposition of environmental tax, firms switch from fossil fuels to renewable energy consumption. As a result the use of fossil fuels reduces in the production sector leading to lower energy consumption (Webster and Ayatakshi, 2013).

Table No 1: Results

Equation	**Obs.**	**Parameter**	**RMSE**	**R^2**	**Chi^2**	**P. Value**
EC_{it}	606	5	360.02	0.11	81.77	0.000
PM_{it}	606	4	11.03	0.40	426.44	0.000
Dependent variable		**Independent variable**	**Coefficient**	**S.E.**		**Prob.**
EC_{it}		$ENVTR_{it}$	-32.29	16.5284		0.050
		EEP_{it}	-180.57	46.39		0.000
		POP_{it}	60.39	15.95		0.000
		ACF_{it}	2.59	1.1761		0.020
		AE_{it}	3.22	1.4648		0.020
		$CONS_{it}$	-99.56	89.42		0.260
PM_{it}		EC_{it}	0.010	0.0012		0.000
		$ENVTR_{it}$	-2.970	0.4548		0.000
		FDI_{it}	0.0024	0.01246		0.84
		ACF_{it}	-0.2196	0.01529		0.000
		UN_{it}	-0.0294	0.0336		0.381
		$CONS_{it}$	3.1665	1.7976		0.070
Indirect Effect						
Coefficient			**S.E.**			**Prob.**
-0.3343			0.1757			0.05
Total Effect = Direct + Indirect						
Coefficient			**S.E.**			**Prob.**
-32.62			16.6998			0.05

The coefficient of (EEP_{it}) has negative sign which describe that higher expenditures on environment protection make a decrease in fossil fuels. Expenditures on environmental

regulation urge firms to invest in cleaner technologies and switch expenditures from non-renewable to renewable resources (Bashir et al, 2022). The results of 2nd equation show the direct and indirect effect of environmental tax on environmental quality. The positive sign of energy consumption towards environmental quality revealed that an increase in fossil fuels enhance particular matter in atmosphere that deteriorate environmental quality. When a country depends on non-renewable resources for economic activity then it deteriorate environmental quality (Chien, 2022).

On the other hand, imposition of environmental tax towards environmental quality describes the direct effect. The coefficient of environmental tax has negative sign which indicates that imposition of such tax improve environmental quality. The results revealed that market based solution for pollution reduction play a crucial role. Therefore, government intervene in the market either by the imposition of environmental tax or through the spending on environment protection have significant role for the reduction of particular matters and improvement in environmental quality

5. Conclusion

The study focused on the role of government intervention for pollution reduction in developing countries. The main objective was to analyze the mediating role of energy consumption in environmental tax and environmental pollution nexus. The results of seemingly unrelated regression (SURE) show that imposition of environmental tax reduces pollutants emission and improve environmental quality. The findings revealed that tax on environment reduce the consumption of fossil fuels in the economy. While a decrease in the demand of energy improve environmental quality. So, it confirms the mediating role of energy consumption in the effectiveness of environmental tax for pollution reduction. Therefore, it is suggested that government take fiscal measures such as imposition of tax to tackle environmental issues in developing countries.

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