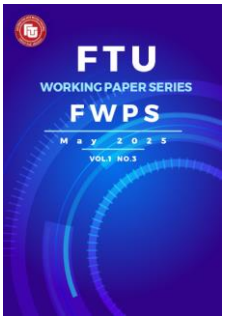

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TÁC ĐỘNG CỦA THUẾ MÔI TRƯỜNG ĐỐI VỚI TIÊU THỤ DẦU TẠI CÁC QUỐC GIA APEC

Phạm Khánh Linh[1], Nguyễn Thị Hương Quỳnh, Lê Hoàng Khang, Vũ Yến Phương

Sinh viên K61 CLC Kinh tế Đối ngoại – Viện Kinh tế và Kinh doanh Quốc tế

Trường Đại học Ngoại thương, Hà Nội, Việt Nam

Nguyễn Thu Hằng

Giảng viên Viện Kinh tế và Kinh doanh Quốc tế

Trường Đại học Ngoại thương, Hà Nội, Việt Nam

Tóm tắt

Mức tiêu thụ dầu cao vẫn là một thách thức nghiêm trọng trên toàn thế giới, do sự công nghiệp hóa nhanh chóng, đô thị hóa và sự phát triển của ngành vận tải. Sự phụ thuộc vào dầu mỏ không chỉ làm trầm trọng thêm suy thoái môi trường và phát thải khí nhà kính mà còn làm gia tăng độ nhạy cảm của nền kinh tế do giá dầu biến động và gián đoạn chuỗi cung ứng. Trong số các nỗ lực khác nhau, việc áp đặt thuế môi trường được coi là một công cụ chính sách hiệu quả để giảm sự phụ thuộc vào dầu mỏ và thúc đẩy các lựa chọn năng lượng sạch hơn, đặc biệt là ở các khu vực tiêu thụ dầu cao. Sử dụng dữ liệu từ các quốc gia APEC, bài nghiên cứu này phân tích ảnh hưởng của thuế môi trường và các yếu tố kinh tế-xã hội khác đến lượng tiêu thụ dầu từ năm 2000 đến 2022. Phân tích sử dụng phương pháp hồi quy Bình phương nhỏ nhất (OLS) và thực hiện các kiểm định như hệ số VIF, Breusch-Pagan và Wooldridge, để đảm bảo độ tin cậy của mô hình. Các phát hiện cho thấy rằng thuế môi trường có ảnh hưởng nhẹ trong việc giảm tiêu thụ dầu ở các nước APEC, phản ánh khả năng của thuế này trong việc khuyến khích sử dụng năng lượng xanh hơn. Ngoài ra, hiệu quả của thuế môi trường bị ảnh hưởng bởi các yếu tố kinh tế xã hội, chẳng hạn như quy mô dân số, phát triển tài chính và độ mở thương mại. Những yếu tố này hoặc làm tăng hoặc giảm tác động của thuế môi trường đối với tiêu thụ dầu ở các nước APEC. Nghiên cứu khuyến nghị rằng các quốc gia APEC nên áp dụng các chính sách thuế môi trường toàn diện, phù hợp với các điều kiện kinh tế-xã hội riêng của họ, để giảm hiệu quả sự phụ thuộc vào dầu mỏ và thúc đẩy phát triển bền vững.

[1] Tác giả liên hệ, Email: k61.2212150103@ftu.edu.vn

Từ khóa: Thuế môi trường, tiêu thụ dầu, các quốc gia APEC

THE IMPACT OF ENVIRONMENTAL-RELATED TAX ON OIL CONSUMPTION IN APEC COUNTRIES

Abstract

High oil consumption remains a critical challenge all over the world, driven by rapid industrialization, urbanization, and the growing transportation sector. This dependency on oil not only exacerbates environmental degradation and greenhouse gas emissions but also heightens economic vulnerability due to fluctuating oil prices and supply chain disruptions. Among various efforts, imposing environmental taxes is widely regarded as an effective policy tool for reducing the dependency on oil and promoting cleaner energy alternatives, particularly in regions with high oil consumption. Utilizing data from APEC countries, this study investigates the influence of environmental taxes and other socioeconomic factors on oil consumption from 2000 to 2022. The analysis employs the Ordinary Least Squares (OLS) regression method and performs diagnostic checks, including the Variance Inflation Factor (VIF), Breusch-Pagan, and Wooldridge tests, to ensure model robustness. The findings reveal that environmental taxes has a slight influence in reducing oil consumption in APEC countries, reflecting the tax's ability to incentivize greener energy use. Additionally, the effectiveness of environmental taxes was influenced by socioeconomic factors, such as population size, financial development, and trade openness. These factors either amplified or mitigated the impact of environmental taxes on oil consumption across APEC countries. The study recommends that APEC nations should adopt comprehensive environmental tax policies, tailored to their unique socioeconomic conditions, to effectively reduce oil dependency and promote sustainable development.

Keywords: Environmental taxes, oil consumption, APEC countries

1. Introduction

A number of fiscal policies have been implemented by governments and policymakers around the world because of the growing concerns about environmental sustainability and the need to manage climate change. Environmental taxes have become one of the most efficient tools among them. These taxes aim to change behavior, hinder excessive use of resources, and encourage the use of green alternatives by adding costs to environmentally destructive behaviors like burning fossil fuels. Taxes on the environment are central in cutting the demand for fossil fuels and financing a shift towards greener energy because the consumption of oil is among the top greenhouse gas emitters in the world.

Countries play a key role in the global conversation over oil use and sustainability, especially those in Asia-Pacific. The area is one of the main emitters of greenhouse emissions and consumes more than 40% of the world's oil, both have a significant impact on climate change (IEA, 2023). While developing nations like Vietnam are just in the first stage of implementing environmental taxes, developed nations like Canada and Japan have already enforced sophisticated taxes to reduce emissions, achieving a balance between sustainability and economic growth (OECD, 2023; World Bank, 2023).

Many studies on environmental tax with energy consumption, carbon footprint, and industrial green transformation have been conducted in Europe and other developing countries; thus, a small number of studies focus on the APEC area. Furthermore, the particular aspect of oil consumption and environmental tax has no limit to investigations. Therefore, the importance of a study on whether the environmental tax affects oil consumption in APEC countries arises along with the question of to what extent does the environmental tax influence oil use. The paper is going to use data covering 2000 - 2022 within the APEC region to fulfill the research and fill in the gap.

In a bid to bridge this gap and guide the study, the following research questions have been formulated:

1. To what extent do environmental taxes influence oil consumption in APEC countries?

2. What policy recommendations can be proposed to optimize the impact of environmental taxes on oil consumption in the APEC region?

The paper follows this format: Section 2 consists of the environmental taxation literature and its impacts on oil consumption within the APEC economies. Section 3 shows the study's theoretical framework, while Section 4 provides the specified method used in the analysis. Section 5 illustrates and summarizes the empirical findings, while Section 6 concludes the research and provides a summary with recommendations.

2. Literature review

Environmental tax on GDP

An environmental tax is a charge put on actions that are considered to be harmful for the environment. It uses financial incentives to promote eco-friendly practices. Environmental taxes naturally have a connection with green consumption and other incentives that damage the environment because of their stated purpose. There have been many empirical studies that researched the impact of environmental tax on energy consumption, carbon footprint, and industrial green transformation…; especially, they paid huge attention to the energy consumption aspect - oil consumption included.

Many studies have argued that environmental taxes will make polluters responsible for the environment, therefore helping to reduce environmental pollution. Taxes on gasoline and oil preserve energy in that manner as the oil and gasoline taxes are energy-saving. The taxes on coal and oil seem to lower CO2 emissions overall, but the tax on natural gas seems to raise them (Sackitey, 2023).

Savko et al. (2019) did research using time series data to examine how changes in environmental tax rates affect emissions of pollutants in the gas and industry, regarding the activities of the gas and oil sector in Ukraine. According to the analysis, higher taxes lower pollution emissions from oil production companies by 0.156%, whereas increases in hydrocarbon output lead emissions to increase by 0.722%, therefore it shows that environmental tax had affected the oil and gas activities of firms in selected areas. Huseynov et al. (2021) also stated that one of the best strategies for modifying energy consumption is still environmental

taxation. They also affirmed: Significant empirical research demonstrates that the decrease in oil and gas production and consumption is due to higher environmental taxes. The effects of energy taxes on energy use were also investigated by Peng et al. (2019). According to the empirical results, energy-related taxes lower carbon emissions in the nations selected and energy taxes may lower the use of fossil fuels. Zhao (2017) conducted research on the impact of gasoline consumption taxes on consumption and carbon emissions during the time when oil prices were low. The outcome demonstrates that during the period of low crude oil prices, the elasticity of gasoline demand is not as strong. However, given China's massive carbon emissions, changing taxes can still have an impact on both CO2 emissions and gasoline usage. In all, the environmental tax is expected to have a negative impact on oil consumption.

H1: Oil consumption is negatively influenced by environmental tax

GDP

Numerous investigations have examined the relationships between energy use, trade, financial development, and economic growth in both developed and developing countries. Henrique and Sadorsky (2008) used data from 1980 to 2005 to examine how real oil prices and GDP affected the consumption of renewable energy in G7 nations. The research discovered that while real oil prices had a negative impact on the renewable energy consumption, real GDP was a significant long-term determinant of renewable energy usage. In addition, according to Magazzino (2016), rising oil prices and real GDP have an important long-term impact on the consumption of energy. In all, GDP is expected to follow trends with oil consumption.

Population

Population is a critical control variable in energy consumption studies because it directly influences the scale of energy demand. A larger population typically leads to higher energy consumption due to increased demand for transportation, heating, cooling, and industrial activities (Sadorsky, 2013). In the context of oil consumption, population growth is expected to have a positive impact, as more people require more energy for daily activities and economic production. To strengthen this statement, the connection between energy use and population has been demonstrated in numerous studies. Urbanization's effects on renewable and non-renewable energy usage following the OECD countries (APEC included) were examined by Sahar and Salim (2014) using the STIRPAT model and data from 1980 to 2011. They found that population density, urbanization, and total population all had a considerable impact on non-renewable energy consumption, with a conclusion that population growth and income rise are major factors driving the energy demand, with significant implications for resource use, economic growth, and environmental sustainability. In all, population growth is expected to have a positive impact on oil consumption.

H2: Population has a positive impact on oil consumption.

Financial Development Index

Financial development is included as a control variable because it reflects the maturity of a country's financial system, which can influence energy consumption patterns. A well-developed financial system facilitates investment in energy-intensive industries and

infrastructure, potentially increasing oil consumption. Shahbaz et al. (2017) estimated the effect of energy consumption on the Indian economy using the nonlinear autoregressive distributed lag bounds testing approach. They found that only negative shocks in energy consumption had an effect on financial development and economic growth. On the other hand, Wang et al. (2021) established the findings that there could be a time-dependent relationship between economic growth and energy use. The authors came to the conclusion that if it is short-term, there is a negative relationship between economic growth and the use of renewable energy, while in the long-term, they become a positive correlation. In terms of the 23-year period we had in this paper, the financial development index is expected to have a positive impact on oil consumption.

H3: Financial development has a positive impact on oil consumption.

Trade Openness

Trade openness is included as a control variable because it reflects a country's integration into the global economy, which can significantly affect energy consumption. To strengthen this, many researchers have demonstrated that trade openness has a considerable impact on energy consumption. According to Rafindandi and Ozturk (2017), trade openness and financial growth both raise energy consumption in South Africa, while affluence and energy consumption are positively linked. In contrast, the empirical results from Shahbaz et al. (2013) show that economic expansion and energy use increase CO2 emission, while trade openness and financial development reduce them. Given the diverse trade policies and economic structures among APEC countries, controlling for trade openness helps account for these varying impacts on oil consumption. In all, trade openness is expected to have a negative or positive relationship with oil consumption.

H4: Trade openness has a negative or positive relationship with oil consumption.

3. Situation of Environmental Tax implementation across APEC countries

Looking at how environmental taxes are being put into place across APEC economies, it's clear there's a big difference between developed and developing countries. This gap is shaped by their different policy approaches, institutional capabilities, and economic priorities. Developed countries like Canada, Australia, Japan, South Korea, Singapore, and the U.S. usually have comprehensive environmental tax systems. These systems often feature higher rates, cover more sectors, and recycle revenue strategically. Take Canada, for example. Their federal carbon pricing is set to rise to CA$170 per tonne by 2030, and they use the revenue to provide household rebates. This helps ease any public resistance while successfully cutting emissions without hurting economic growth (Environment and Climate Change Canada, 2023).

Similarly, Singapore is aiming for a carbon tax that will hit US$170 per tonne by 2030, with revenues again used for household rebates—as a way to balance industrial competitiveness with climate goals (NCCS, 2023). Developed economies often coordinate their tax policies with international climate agreements, and we can see a steady increase or at least stabilization in environmental tax revenues as a percentage of GDP since 2010 based on the available data.

On the flip side, developing APEC countries like Chile, Mexico, China, Peru, the Philippines, and Hong Kong face serious challenges in creating and enforcing effective environmental taxes. Take China's Environmental Protection Tax Law from 2018 as an example.: it lets provincial governments decide tax rates, which can lead to a mixed bag of enforcement. In industrial centers like Beijing, emissions have dropped by about 15% in key sectors, but in less developed areas, compliance tends to lag (Wang et al., 2024). Mexico and Chile illustrate the challenges of merely symbolic carbon pricing. Mexico's US$3-4 per tonne tax only covers 40% of emissions and excludes non-energy sectors, and both countries are undercut by fossil fuel subsidies and tax evasion (OECD, 2019; World Bank, 2023).

The Philippines and Peru have their own struggles with administrative challenges. For instance, in the Philippines, the coal tax doesn't apply to power generation, and Peru's US$2 per tonne tax on distributors lacks solid monitoring systems, showing that often, economic stability takes precedence over environmental efforts (Malerba, Gaentzsch and Ward, 2020). As a result, environmental tax revenue in these countries is often unpredictable, sometimes stagnating or even dipping when the economy takes a hit, as seen with Mexico's drop in revenue after 2009.

The real difference lies in how these taxes are designed and how the revenue is used. Developed economies typically use escalating rates and reinvest the money in green projects or public rebates, which not only makes the taxes more effective but also more politically acceptable. Canada's approach, which aims to be revenue-neutral, and Singapore's targeted decarbonization funding are great examples of this. However, many developing countries stick with low-rate, static taxes that don't reach many sectors and usually funnel the money into general budgets rather than environmental initiatives. For example, in China, provincial tax rates can vary quite a bit, and even though Hong Kong is advanced economically, it relies on waste disposal charges instead of having a carbon tax, aiming to cut down landfill use by 40% by 2025 through a solid waste levy (HK EPD, 2022). This patchy approach emphasizes how lobbying, informal practices, and growth-focused policies can shape environmental taxation practices.

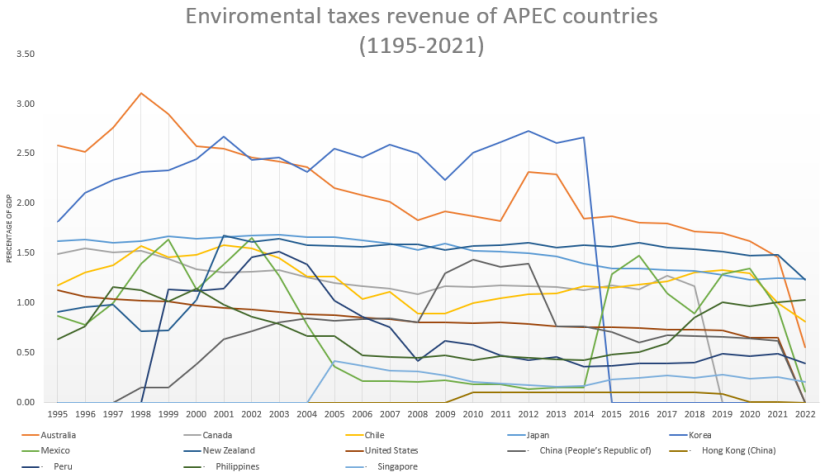

Figure 1: Environmental taxes revenue per GDP of APEC countries

Source: IMF

The dataset shows trends from 1995 to 2022 really emphasize these differences. Developed nations show solid revenue growth, often in line with global climate accords like the Paris Agreement. Japan's carbon tax, while low at ¥289 per tonne, along with South Korea's hybrid K-ETS and coal taxes show gradual advancements, as the latter saw a 6% emissions reduction in regulated sectors by 2023 (InfluenceMap, 2023). In contrast, developing countries struggle with structural inertia: for example, Peru's carbon tax started in 2019 but hasn't considerably reduced emissions due to tax evasion, while the Philippines has seen its revenue plateau since 2018 due to stagnant policies. Even in high-income economies like Hong Kong and Singapore, there's a stark difference—Hong Kong doesn't have a carbon tax, while Singapore actively prices carbon emissions, showing how political will can really shape the outcomes.

The APEC region's environmental tax landscape exhibits a development divide. Strong, adaptive institutions are used by the developed nations to pursue climate goals, whereas developing economies confront structural constraints and competing priorities.

4. Theoretical framework

4.1. Theoretical framework on oil consumption

4.1.1. Overview

Oil consumption refers to the utilization of crude oil and petroleum products for energy purposes, driven by demand in key sectors such as transportation, industry, and heating (IEA, 2023). Environmental taxes, including carbon or fuel taxes, are increasingly employed as policy tools to reduce oil consumption by raising the cost of oil-based fuels and incentivizing the adoption of cleaner energy alternatives (OECD, 2021). This framework investigates the economic, sectoral, and behavioral effects of environmental taxes on oil consumption patterns.

4.1.2. Characteristics of Oil Consumption

Oil consumption is characterized by its sectoral drivers, global demand, environmental impact, and price sensitivity. The transportation, industrial, residential, and power generation sectors are the primary drivers of oil demand due to their energy density and widespread infrastructure (IEA, 2023). Globally, oil remains a dominant energy source, though its consumption contributes significantly to greenhouse gas emissions, pollution, and climate change (OECD, 2021). Oil demand is also highly sensitive to price fluctuations, which can be influenced by environmental taxes and market dynamics (Sterner, 2007).

4.1.3. Rationale for Using Environmental Taxes to Reduce Oil Consumption

Environmental taxes are a critical tool for reducing oil consumption due to their ability to create economic incentives, drive behavioral shifts, generate revenue for sustainable investments, and send clear market signals. By increasing the cost of oil-based fuels, these taxes encourage energy efficiency and the adoption of substitutes like renewables (Sterner, 2007). They also influence consumer and industrial behavior, promoting cleaner alternatives such as electric vehicles, public transport, and renewable energy systems (Creutzig et al., 2015). Additionally, tax revenues can be reinvested in sustainable infrastructure, such as public transportation or renewable energy projects, further reducing oil dependence (Parry et al.,

2014). Finally, environmental taxes send clear price signals to producers and consumers, fostering innovation in energy-efficient technologies and cleaner energy sources (Newell et al., 1999).

4.1.4. Economic Principles

Environmental taxes increase the cost of oil, making alternatives like natural gas or electricity more attractive and reducing oil demand (Goulder & Schein, 2013). They also encourage energy efficiency and innovation, as businesses and consumers seek ways to avoid higher costs (Newell et al., 1999). For example, higher fuel taxes can lead to a shift toward electric vehicles or public transport (Creutzig et al., 2015). While these taxes primarily target consumers, they can also indirectly affect global oil markets by reducing demand, which may lower production levels over time (BP, 2022).

4.1.5. Sectoral Impacts

Environmental taxes influence various sectors by encouraging shifts toward more sustainable practices. In transportation, higher fuel costs discourage excessive driving and promote the adoption of fuel-efficient or electric vehicles. Additionally, the revenue from these taxes can support public transportation improvements, further decreasing oil dependence (IEA, 2023; Sterner, 2007). In the industrial sector, rising energy costs push businesses to enhance efficiency or transition to cleaner energy sources (OECD, 2021). Likewise, in residential and commercial settings, increased taxes on heating oil encourage investments in energy-efficient buildings and renewable heating technologies such as heat pumps (Parry et al., 2014). In power generation, these taxes enhance the competitiveness of renewable energy, ultimately reducing the reliance on oil for electricity production (Goulder & Schein, 2013).

4.1.6. Policy Considerations

For environmental taxes to be effective, they must be carefully designed. This includes setting appropriate tax rates, addressing potential regressive impacts on low-income households, and using revenues to fund sustainable initiatives (Parry et al., 2014; OECD, 2021). Additionally, since oil markets are global, international cooperation is essential to maximize the impact of these taxes and address cross-border challenges (IEA, 2023).

4.2. Theoretical framework on ET

4.2.1. Overview of environmental tax

Environmental tax, also known as environmentally related taxes, refers to any compulsory, unrequited payments made to the government and levied on tax bases of particular environmental relevance (OECD, 2004). The European Commission defined environmental taxes as “any tax with a tax base consisting of a physical unit that harms the environment, which the European System of Accounts can also identify as a tax.” This term emphasizes how these levies affect the price of activities and the harm that particular behaviors or goods cause to the environment. Furthermore, these taxes' effects on price elasticity and relative product prices have an influence on the environment.

Environmental taxes are also called Pigovian tax (The European Commission, 2013) - a tax that is levied on any market activity that produces negative externalities (Morley, 2012).

This tax is applied at a rate equivalent to the marginal damage cost, aiming to correct market inefficiencies.

4.2.2. Characteristics and main categories of environmental taxes

Such taxes encompass tax revenue, tax base, tax rates, and exemptions. They are applied to several environmental domains such as energy products, transport services, measured or estimated emissions to air and water, ozone-depleting substances, certain non-point sources of water pollution, waste management, and noise, as well as management of water, land, soil, forests, biodiversity, wildlife, and fish stocks. (OECD, 2004)

According to Dyduch & Stabryła-Chudzio, environmental taxes have 4 primary categories: energy, transport, pollution, and resources.

4.2.3. Rationale for using environmental taxes

Environmental taxes serve as effective tools for internalizing externalities by incorporating the costs of environmental damage or associated repairs directly reflected in the prices of the goods, services, and activities that cause such harm. This mechanism not only aligns with the Polluter Pays Principle but also promotes the convergence of economic and environmental policy, (European Environmental Agency, 1996). Furthermore, such taxes provide incentives for both consumers and producers to shift toward more eco-efficient behaviors, thereby stimulating innovation and driving structural changes. They also play a crucial role in reinforcing compliance with environmental regulations through economic disincentives for environmentally harmful actions.

In addition to their environmental benefits, these taxes generate significant revenue streams for governments, which can be allocated to environmental expenditures or used to reduce other taxes, such as those on labor, capital, or savings. For instance, in 2022, the EU received €317.2 billion in total revenue from environmental taxes, which was equivalent to 2.0% of GDP and 4.8% of overall government revenue from taxes and social contributions.

5. Methodology

5.1. Research Methodology

The research uses panel data from APEC countries from 2000 to 2022, covering 23 years and 13 countries, which are Australia, Canada, Chile, Japan, Korea, Mexico, New Zealand, United States, China (People's Republic of), Hong Kong (China), Peru, Philippines and Singapore.

Ordinary least squares (OLS) regression was used in this initial analysis to evaluate the connection between the independent variable and dependent variables. The model was subsequently put under diagnostic tests in order to identify potential issues including autocorrelation using the Wooldridge test, heteroskedasticity using the Breusch - Pagan test, and multicollinearity using the variance inflation factor (VIF). If any of these occur, the Robust Standard Errors Model will be used to address the heteroskedasticity and autocorrelation issues.

Finally, the Generalized Method of Moments (GMM) will be used to test whether the model contains any endogenous factors.

5.2. Research Model

According to the literature review and theoretical model, the OLS model to examine the impact of environmental-related tax revenue on APEC's oil consumption can be expressed as:

$$ln\ oil\ = \beta_0\ + \beta_1 lnettogdp\ + \beta_2 ln\ pop\ + \beta_3 Tradeopenness + \beta_4 ln\ findev\ + \varepsilon$$

In which:

- $ln\ oil$ (Dependent variable): Natural logarithm of the oil consumption in 13 countries.
- $lnettogdp$: Natural log of environmental related tax revenue to GDP ratio. Environmental related tax revenue has the potential to limit oil consumption by causing fuel to be more costly, discouraging the usage of fossil fuels, and promoting cleaner energies. Prior studies have shown that higher environmental related tax revenue lowers oil dependence (Xie & Yao, 2020; Lin & Li, 2011).
- $ln\ pop$: Natural log of population. As populations continue to grow, it leads to more energy needs for transport, manufacturing, and all activities. Evidence from research that population growth leads to a higher demand for oil in the economies. (York et al., 2003; Liddle & Lung, 2010).
- $Tradeopenness$: Global trade can enhance technology transfer and green energy adoption, resulting in a reduction in fossil fuel consumption (Zhang & Zhou, 2022).
- $lnfindev$: Natural logarithm of financial development index. Studies show that financial development increases oil consumption by driving economic growth, enhancing capital flow, and boosting investments (Sadorsky, 2010).
- β_0: The intercept of the regression model.
- $\beta_1 - \beta_4$: Regression coefficients of the independent and control variables.
- ε: The error term for country i in year t, capturing all other unobserved factors affecting oil consumption that are not included in the model

5.3. Data and data source

This analysis examines the factors influencing oil consumption, including environmental-related tax revenue, GDP, population, financial development index, trade openness, exports, and imports, as detailed in the table below.

The data originates from various sources, including the OECD, World Bank, IMF, CEIC, BP PLC, and national trade statistics.

Table 1. List of variables and sources

Variables	Meaning	Unit	Expected sign	Source
Oil consumption	The usage of fuel in engine operation.	Barrel/Day		CEIC (active status) and BP PLC
Environmental-related tax revenue to GDP	The ratio of environmental-related tax to GDP revenue	US dollar, Millions	-	OECD
Population	Total population based on the de facto definition.	Million people	+	World Bank
Financial Development Index	An index that tracks the progress of the financial industry.	Index value	+	IMF
Trade Openness	A ratio of total trade (exports + imports) to GDP.	Percentage	-	World Bank

Source: Compiled by the author

6. Result

6.1. Descriptive Statistics

The study examined data from APEC countries over 23 years, from 2000 to 2022. The dataset includes 299 observations for each variable, providing a solid basis for analysis. While some data was missing, the amount was small and did not affect the study's reliability. A detailed summary of the key variables used in the model is shown in the table below.

Table 2. Descriptive statistics results

Variable	Obs	Mean	Std. Dev.	Min	Max
lnoil	299	7.077968	1.470211	4.87099	9.929715
lnettogdp	299	-4.86481	1.029485	-10.84376	-3.477845
lnpop	299	3.76516	1.599847	1.350071	7.253017
lnfindev	299	-0.5038959	0.4000485	-1.604555	-0.0259139
Tradeopenness	299	101.3998	113.5769	19.5596	442.62

6.2. Correlation matrix

Table 3. Variables correlation matrix

	lnoil	lnettogdp	lnpop	lnfindev	Tradeopenness
lnoil	1.0000				
lnettogdp	-0.1898*	1.0000			
lnpop	0.7542*	0.2078*	1.0000		
lnfindev	0.2827*	0.0854*	-0.2344*	1.0000	
Tradeopenness	-0.2661*	-0.7035*	-0.5571*	0.2308*	1.0000

Source: Authors' calculation, 2025

*: All the value is adjusted at a 5% level of significance

All variables have correlations below 80%, indicating no significant multicollinearity, making the dataset suitable for further research.

6.3. Multicollinearity testing

Table 4. Variance Inflation Factors result

Variable	VIF	1/VIF
Tradeopenness	3.42	0.292598
lnettogdp	2.47	0.404079
lnpop	1.61	0.622255
lnfindev	1.21	0.824775
Mean VIF	2.18	

Source: Authors' calculation, 2025

The table shows that the VIF values for all independent variables are below 5, indicating that multicollinearity is not present in the model.

6.4. Heteroscedasticity and autocorrelation testing

Table 5. Heteroscedasticity and autocorrelation testing

Breusch-Pagan/Cook-Weisberg test	Prob > chi2	0.3033
Wooldridge test	Prob > F	0.0000

Source: Authors' calculation, 2025

The authors conducted diagnostic tests for deficiency in the model, specifically the Breusch-Pagan/Cook-Weisberg test for heteroskedasticity and the Wooldridge test for autocorrelation. The model was found to exhibit one deficiency about correlation. Therefore, the authors performed regression using the Robust Standard Errors Model in the table below.

6.5. Regression results and endogenous regressor testing

Table 6. Regression results after robust

Variable	Coefficient	Std. Error	95% Confidence Interval	
lnettogdp	-0.2162	0.04698	0.1237	0.3087
lnpop	0.9058	0.02474	0.8571	0.9545
lnfindev	1.5952	0.09523	1.4077	1.7826
Tradeopenness	-0.0037	0.00056	0.0026	0.0049
(_cons)	5.1431	0.1808	4.7873	5.4989

Source: Authors' calculation, 2025

To test whether there are any endogenous variables in the model, the author applied the Generalized Method of Moments method to test the data. The GMM test's final result demonstrated that the model has no endogenous variables. The results are presented in the table below.

Table 7. GMM model

Variable	Coefficient	Std. Error	95% Confidence Interval	
lnettogdp	-0.2162	0.05544	0.1075	0.3248
lnpop	0.9058	0.02875	0.8494	0.9621
lnfindev	1.5952	0.09987	1.3994	1.7909
Tradeopenness	-0.0037	0.00059	0.0026	0.0049
(_cons)	5.1431	0.22486	4.7024	5.5838
R-squared = 0.8179				

(no endogenous regressors)

Source: Authors' calculation, 2025

OLS regression results show that environmental-related tax revenue (lnettogdp) is statistically significant on the consumption of oil in APEC countries but slightly. From the findings, this association is moderated by a range of variables like population (lnpop), financial development (lnfindev) and trade openness (Tradeopenness).

Notably, lnpop and lnfindev exhibit a major positive impact on consumption of oil, implying that enhanced population and fiscal development propel the demand for energy even after an environmental tax is imposed. This is congruent with previous literature highlighting the significance of fiscal development and increasing the consumption of energy (Sadorsky, 2010; Islam, 2010). By contrast, trade openness impacts on the opposing side implies international trade integration works to lower demand for oil (Zhang & Zhou, 2022).

7. Discussion

The regression analysis reveals the influence of four critical independent variables on oil consumption. These variables - Environmental Taxes Revenue to GDP (lnettogdp), Population (lnpop), Financial Development Index (lnfindev), and Trade Openness (Tradeopenness) - all significantly predict oil consumption, as demonstrated by P-values below the 0.05 threshold.

7.1. Impact of Environmental Taxes on Oil Consumption

The model indicates a negative correlation of -0.2162 between environmental taxes and oil consumption in APEC countries, aligning with the initial hypothesis. This suggests that higher environmental tax revenue is associated with lower oil consumption, reinforcing the idea that taxation can serve as a deterrent to fossil fuel reliance. However, the relatively small magnitude of this coefficient suggests that the effectiveness of environmental tax depends on complementary policies, including the tax rate, policy enforcement, and regulations.

A well-structured carbon tax discourages excessive oil usage by making fossil fuels more expensive and encouraging industries and consumers to switch to energy-efficient alternatives. APEC countries such as Sweden and Canada, which have implemented progressive carbon pricing, have witnessed a significant decline in oil demand over time. Sweden's high carbon tax has led to a 27% reduction in fossil fuel consumption over the past three decades (Jonsson, 2023). Similarly, Canada's carbon tax reached C$80 per ton in 2024, and is set to rise to C$170 per ton by 2030, has already contributed to a decline in transportation fuel demand, particularly in urban areas where public transportation and electric vehicle infrastructure are more developed (Environment Canada, 2023).

However, the effectiveness of carbon tax varies across APEC countries. In nations where carbon taxes are low or inconsistently enforced, such as Mexico and Indonesia, the impact on oil consumption remains limited. Mexico's carbon tax of only $3-4 per ton covers only 38.2% of greenhouse gas (GHG) emissions, and the continued presence of fossil fuel subsidies weakens the tax's intended effect. Likewise, China's Environmental Protection Tax Law (2018) grants provincial governments the authority to set their own tax rates, leading to uneven enforcement and varied effectiveness. While industrial regions such as Beijing have recorded a reduction in emissions, less developed provinces have shown little change due to weak regulatory oversight (Chenghao, Mayburov and Ying, 2024)

7.2. Population Growth and Oil Consumption

The coefficient of 0.9058 highlights a strong positive correlation between population size and oil consumption. This result is expected, as larger populations require more transportation, energy for household use, and industrial output. Rapid urbanization and economic expansion further drive oil demand, particularly in developing economies such as China, the Philippines, and Vietnam. The findings underscore the necessity of energy diversification strategies, such as expanding public transport infrastructure and promoting electric vehicle adoption, to mitigate increasing oil dependency as APEC populations continue to grow.

7.3. Financial Development and Oil Consumption

The positive coefficient of 1.5952 suggests that financial development contributes to higher oil consumption. This finding implies that as financial systems mature, they facilitate greater investment in industries that are traditionally energy-intensive, such as manufacturing, logistics, and construction. While financial development accelerates economic growth, it also increases energy demand, necessitating targeted policies to direct investments towards low-carbon technologies and energy-efficient industries. Countries such as Japan and South Korea have successfully balanced financial growth with environmental sustainability by integrating green finance initiatives and carbon trading systems, reducing oil dependency while maintaining economic competitiveness (Korea's Green Growth Experience:Process, Outcomes and Lessons Learned, no date; Schumacher, 2020).

7.4. Trade Openness and Oil Consumption

The model identifies a negative correlation of -0.0037 between trade openness and oil consumption, suggesting that greater economic integration does not necessarily lead to higher oil usage. While international trade stimulates production and transportation activity, leading to increased energy demand, economies that prioritize sustainable trade policies - such as carbon border adjustments and clean energy incentives - can offset this effect. For example, Singapore's green port initiatives and China's renewable energy export strategy have helped reduce oil dependency despite growing trade volumes.

8. Conclusion and Implications

8.1. Conclusion

According to the analysis, environmental taxes help APEC countries move to sustainable energy by encouraging energy efficiency, the use of cleaner energy sources, and changes in consumer and industrial behavior. These tariffs encourage industries to use energy-efficient technologies and renewable energy by boosting the cost of petroleum-based fuels. While implementing environmental taxes may have short-term costs, such as administrative overhead and disruptions in fossil fuel-dependent companies, the long-term benefits are substantial. Reducing oil use boosts energy security, stimulates clean technology research, and generates new green jobs. The revenue from these levies can be spent in long-term infrastructure and health programs, thereby promoting economic growth. However, the success of these levies is heavily dependent on their design, administration, and integration with supportive policies such as renewable energy targets and public transportation improvements.

8.2. Implications

Our findings imply that environmental levies can assist APEC countries in achieving both environmental and economic goals by reducing oil use. We advocate a systematic approach to imposing these tariffs, weighing short-term economic obstacles against long-term environmental benefits. This includes researching the expansion of environmental protection levies on commodities related to oil consumption and contemplating changes to tax regimes and rates. Depending on the growth rate and background of each country, a phased

implementation accompanied by targeted intervention, which includes economic support measures like grant funding or revenue allowances for clean technology adoption, is likely able to address the likely adverse effects on the economy. These countries must coordinate their taxation policies to eliminate tax competition while establishing a competitively optimal regime that encourages investment into renewables and at the same time reduces oil usage.

To attain the desired results, APEC member nations should combine environmental taxes with renewable energy policy and reinvest tax revenues in infrastructure for electric vehicles, renewable energy, and energy efficiency. This strategy will minimize oil reliance, promote innovation, create green jobs, and improve the green economy. Furthermore, public awareness initiatives are critical to ensuring that citizens understand how reducing oil usage benefits air quality and energy security. These initiatives will motivate people to support the green transition.

Finally, APEC countries should coordinate their tax policies regionally, modifying tax rates based on oil consumption data. This data-driven approach will allow tax arrangements to be tailored to local needs. By combining these measures - regional coordination, renewable energy investments, public awareness campaigns, and responsive policies - APEC member countries may effectively reduce oil consumption, accelerate economic growth, and achieve sustainability.

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