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The Effect of Taxes and Tax Refunds on the Economic Activity of the Energy Industry in Peru

Victor Hugo Puican Rodriguez[1]*, Liliana del Carmen Suárez Santa Cruz[1], Abel Salazar Asalde[1], Alejandro Alcántara Suyón[1], Freddy Manuel Camacho Delgado[2]

[1]Cesar Vallejo University, Peru, [2]Fabiola Salazar Leguía National Intercultural University, Peru. *Email: vpuican@ucv.edu.pe

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ABSTRACT

Through an empirical analysis of the impact of taxation and tax refunds (TR) on the economic activity of the energy industry in Peru, this study seeks to provide an understanding of the economic effects of fiscal policies in a Latin American country with a significant energy sector. Relevant data on taxation and TR in the Peruvian energy sector were collected and the effect of these variables on the main indicator of economic activity in the industry was evaluated. The results suggest that both taxation and TR can significantly impact the economic activity of the energy industry, however, these effects are full when the output of this industry is at medium levels. In addition, the regressive effects of tax taxation can be offset by the positive effects of TR. Overall, this research contributes to understanding the dynamics of fiscal policies in the energy sector of developing economies such as Peru, emphasizing the importance of tailored fiscal measures to promote sustainable energy development and economic growth.

Keywords: Taxation, Tax Refunds, Energy Industry, Peru
JEL Classifications: C32; O13; H23

1. INTRODUCTION

Peru's economy, intrinsically linked to energy production, has experienced a deep and complex relationship with the performance of the energy sector.[1] In the current context in which the transition to more sustainable and renewable energy sources has been at the centre of political and economic agendas globally, understanding the impact of taxation on this sector is of vital importance. As Peru seeks to strengthen its position in the energy market and promote investment in diversified and sustainable energy sources, it is imperative to understand how fiscal policies impact the production, investment, and competitiveness of the energy industry. Tax policies and tax refund (TR) measures can have significant effects on the investment, production and competitiveness of energy companies, as well as on the economy as a whole. In this article, we propose to analyze how taxation and specific TR applied to the energy industry affect the gross domestic product (GDP) of this sector in the peruvian economy.

We examine the relationship between tax burden, TR, and economic activity in the energy industry, exploring how these factors interact to influence the growth and stability of the sector. In doing so, we seek to shed light on the mechanisms through which fiscal policy can be used to promote sustainable and resilient development in the energy industry, in line with the objectives of economic growth and environmental protection.

1. According to the Supervisory Agency for Investment in Energy and Mining (Osinergmin), electricity consumption in Peru increased between 2005 and 2021 at an average annual growth rate of 5.4 percent (from 20.7 TWh to 48 TWh). According to the National Energy Plan of the Ministry of Energy and Mines, by 2025, 60% of the production of electricity will come from hydroelectricity. This is a sustainable source in favor of environmental conservation in Peru. The supply in the electricity market in the country is favorable and the efforts of the State, together with private companies, point to growth in the coming years. For more information: https://www.bcrp.gob.pe/docs/Publicaciones/Revista-Moneda/moneda-193/moneda-193-08.pdf

The strategic importance of this research lies in its potential to inform more resilient and sustainable energy sector fiscal incentive policies. By unraveling the complex links between output and taxation in the energy sector in Peru, it is intended to provide a solid empirical basis for government decision-making and the design of strategies that mitigate the risks associated with contractionary taxation and foster diversification and economic competitiveness in energy production.

The interaction between fiscal policy and the energy industry has been the subject of extensive analysis in the academic literature, especially in the context of Latin America. Numerous studies have investigated how tax policies and TR impact the economic growth of the energy industry in various developing countries. Research by Domingues (2007) and Pereira et al. (2011) for Brazil indicates that taxation has the potential not only to impact the energy industry as a whole, but also to stimulate the use of some energy sources in particular, such as renewables. Davis and Lund (2018), in their study of several OECD countries, show how a favorable tax framework can not only boost the growth of the oil industry, but also contribute to the overall economic development of countries.

In a different context, Price et al. (2005) conducted detailed research for the Chinese market with the aim of understanding the impact of fiscal policies on competitiveness and energy production. Their findings highlighted the importance of a well-designed tax system and efficiency in refunds to encourage investment and innovation in the energy sector, resulting in an increase in sectoral GDP and ultimately the country's economic growth. On the other hand, in Zhao (2011) the author addresses the challenges faced by industries due to tax uncertainty and the lack of clear TR in the carbon tax. Their study identified that instability in the fiscal framework can lead to disincentives for investment and production in the sector, resulting in lower GDP growth in the energy industry. These findings underscore the importance of consistent and predictable fiscal policies to ensure an enabling environment for sustainable development of the energy sector, particularly in developing countries.

In order to contribute to the growing literature examining the impact of taxation and tax incentives on the energy economy and production of developing countries, this study focuses on comprehensively analyzing the effects of taxes and TRs on the output of the energy sector for the Peruvian economy. Unlike previous research focused on firm-level industrial analyses, this research takes a sectoral approach using time series analysis to understand the dynamics of these influences over time.

For this, we use monthly data from Peruvian public sources. The empirical strategy is divided into three parts with a time series approach. Initially, we performed ordinary least squares (OQS) and generalized moment methods (GMM) estimates with newey west matrices to assess the effects of net taxation (tax taxes [TT] minus refunds) on competitiveness in Peru's energy industry. Subsequently, we use similar models to assess the differentiated effects of taxes and TRs on production in the energy sector. In addition, we implemented a quantile regression to examine how the impacts of net taxation vary across different quantiles of the energy industry's GDP, allowing us to better understand the distribution of these effects across the economic spectrum.[2]

The structure of the article is organized into four essential sections: The introduction, which presents the problem addressed and highlights the relevance of the study in the economic context of Peru; a historical context that examines the evolution of tax and fiscal laws and their effects on the Peruvian economy; a theoretical framework that explores the well-known impacts of taxation and tax incentives on economic and energy variables; methodology, which details the data and methods used in the econometric analysis; the results, which present and explain the empirical evidence obtained by the implemented models, discussing the main findings and reflecting on their scope and implications; and finally, the conclusions, which summarize the contribution of the study and propose possible directions for future research in this field.

2. BRIEF HISTORY AND CONSIDERATIONS ON TAXATION AND TAX REBATES IN PERU'S ENERGY INDUSTRY 2010-2022

In general terms, the tax issue is a complex matter to analyze in cases such as the Peruvian market, and if we look at it from the different levels of social and economic disaggregation, various variables may be found influencing the dynamics of tax collection, whether in the different economic levels of the firms, in tax culture or even in the problem of informality and deficit of tax solidity in governmental institutions (Neira Cruz et al., 2022; Perez Jimenez and Puican Rodriguez, 2022; Roca and Simabuko, 2023). During the period between 2010 and 2022, Peru underwent a number of significant changes in its tax policy regarding the energy sector. These modifications were carried out in different economic contexts over the years but with the constant increase in energy demand and a growing interest in the exploration and exploitation of natural resources. The period was marked by a series of reforms and fiscal adjustments that sought to adapt to the dynamics of the energy market and encourage investment in this strategic sector for the country's development. These changes, which will be described in more detail below, were driven by a variety of factors, including changes in international oil prices, the evolution of renewable energy technology, and ever-changing environmental and social demands.

Tax reforms during the first 4 years of the 2010s were geared towards promoting investment and competitiveness in the energy

2. It is common in time series studies for more than one regression method to be used to address the complexity of the data and adequately capture the dynamic relationships between variables. Given the multifaceted and dynamic nature of economic phenomena, the use of multiple regression methods allows for a more comprehensive exploration of the underlying patterns and interactions between variables over time. This may include the application of techniques such as Ordinary Least Squares (OQS), Generalized Moment Methods (GMM), as well as quantile regression analysis, each with its own advantages and to model different aspects of the data. The combination of these approaches provides a more complete and robust perspective of the phenomenon under study, allowing for a deeper interpretation of the results and a better understanding of the underlying causal relationships.

sector, while seeking to ensure the country's fiscal sustainability. One of the important milestones during this period was the enactment of Law No. 29783, known as the "Energy Sector Reform Law", in 2011. This law introduced significant changes in the sector's tax framework, with the aim of encouraging investment and exploration of energy resources. Tax rebate mechanisms were established for companies investing in energy projects, in order to reduce their tax burden and promote the expansion of the sector.

In addition, specific tax incentives were implemented for the development of energy projects in regions considered priorities for economic growth and social inclusion. In 2010, Law No. 29571 was enacted, which amended the Income Tax (IR) and established a new taxation regime for companies in the hydrocarbons sector. This law established an IR rate of 30% for companies operating under license contracts and 36% for those operating under risk contracts. Various incentives included tax breaks and tax credits for companies investing in energy infrastructure in remote or less developed areas of the country. These measures sought not only to promote private investment in the sector, but also to ensure equitable access to energy throughout the country.

However, despite efforts to promote investment and competitiveness in the energy sector, the period was also marked by challenges and controversies around taxation and TRs. The lack of clarity in tax regulations and the perception of inequity in the distribution of tax benefits generated debate and criticism from various sectors of society. This led the government to review and adjust some of the tax provisions, with the aim of improving the transparency and efficiency of the tax system in the energy sector.

During the period from 2015 to 2019, Peru continued its trajectory of tax reforms with the aim of strengthening the energy sector and promoting sustainable economic growth. These reforms were carried out in a context marked by the volatility of international commodity prices, including oil, and the need to diversify the country's energy matrix towards more sustainable and renewable sources. Fiscal policies during this period focused on providing incentives for investment in energy projects and ensuring equitable taxation that promoted the competitiveness of the sector.

One of the most significant reforms during this period was the revision and modification of tax provisions related to the energy sector in the Sustainable Development Promotion Law of the Energy Sector, enacted in 2016. This law introduced changes in the sector's tax regime, aimed at promoting investment in renewable energies and enhancing energy efficiency. Specific fiscal incentives, such as tax exemptions and tax credits, were established for companies developing clean and sustainable energy projects. Additionally, efforts were made during this period to improve transparency and efficiency in the TR system for the energy sector. Measures were implemented to streamline the TR process for companies investing in energy projects, with the aim of reducing administrative burdens and encouraging greater private sector involvement in the country's energy infrastructure expansion. These initiatives aimed to improve the business climate and promote investment in the energy sector.

Between 2016 and 2017, TRs grew rapidly, equivalent to 20% of the total internal taxes collected by SUNAT.[3] In 2017 alone, refunds exceeded $16 billion, doubling compared to 2011. The mining sector was the main beneficiary of the refunds, capturing 30% of the total. This reflects the impact of mining megaprojects such as the expansion of Cerro Verde and Las Bambas, which have a huge tax credit.[4] However, despite efforts to strengthen the energy sector through tax reforms and TRs, the period was also marked by challenges and controversies. The lack of clarity in tax regulations and the perception of inequity in the distribution of tax benefits generated debate and criticism from various actors in the sector. This led the government to review and adjust some of the tax provisions and to strengthen supervision and control mechanisms to ensure efficiency and fairness in the energy sector's tax system.

During the period from 2020 to 2023, Peru faced a number of economic and fiscal challenges, as well as opportunities to strengthen its energy sector through tax reforms and strategic TRs. In 2020, Law No. 31015 was enacted, marking a significant milestone in the country's legal framework by establishing a new set of incentives to encourage private investment in the electricity sector. This legislation introduced a range of tax benefits aimed at companies committing to renewable energy projects, reflecting the Peruvian government's commitment to transitioning to more sustainable and environmentally friendly energy sources and allowing some flexibility in the face of the crisis caused by the COVID-19 pandemic.

In 2021, another important change took place with the approval of Law No. 31154, which modified the Income Tax with the purpose of reducing the tax burden for companies in the hydrocarbon sector operating under license contracts. This law implied a decrease in the tax rate, going from 29% to 27%, which represented a stimulus for investment and exploration in this strategic sector for the Peruvian economy. This measure not only sought to maintain the competitiveness of the sector, but also to promote greater investment and development in the hydrocarbon industry, thus contributing to economic growth and the strengthening of the energy sector in the country.

Despite these legislative advances, the years between 2020 and 2023 were also marked by challenges and controversies around taxation and TRs. The complexity of the legal framework and the perception of inequity in the distribution of tax benefits generated debate and criticism from various actors in the sector. This underscores the importance of continuing to evaluate and adjust the energy sector's tax system to ensure its efficiency and equity, as well as its ability to promote investment and sustainable

3. The National Superintendence of Customs and Tax Administration (SUNAT) is a specialized technical agency attached to the Ministry of Economy and Finance of Peru. It is responsible for the administration of the internal taxes of the National Government, as well as for the supervision and collection of customs duties and other tax and non-tax concepts entrusted to it by Law or Inter-institutional Agreement.
4. Las Bambas: It is a copper exploitation project located in the Apurimac region, Peru. It is one of the largest mining projects in the world. Cerro Verde Expansion: This is a copper mine expansion project located in the Arequipa region of Peru. It is one of the most important mining investment projects in Peru.

development in line with Peru's national and global energy goals.

Elections and media interventions in Peru are constantly marked by citations to studies that investigate how TT and TRs influence the GDP. First, several studies have highlighted that an excessive tax burden can put pressure on companies, reducing their profitability and ability to reinvest. This can translate into decreased investment in infrastructure, exploration, and new project development, which in turn can slow GDP growth (Metcalf, 2010; Pizer and Sexton, 2019). The literature has also pointed out that fiscal uncertainty resulting from frequent changes in tax policies may further discourage investment and expansion in the energy industry, which could have additional negative effects on economic growth (Fabrizio, 2013; Wen et al., 2022).

On the other hand, the literature has also highlighted the role of TRs as a mechanism to stimulate investment and growth in industries. TRs can provide tax relief to firms, increasing their liquidity and allowing them to reinvest in productive activities, as well as having a positive impact on stock returns (Auerbach and Poterba, 1987; Koch et al., 2023). This can translate into increased investment in infrastructure, technology, and exploration, which in turn can boost GDP growth. In addition, some research has suggested that TRs can improve the competitiveness of firms, easing the financial burden and allowing them to be more flexible and resilient to changes in the economic and regulatory environment (Bethmann et al., 2018; Hillmann and Jacob, 2022; Mvunabandi et al., 2024).

While it is important that tax reforms and TRs are aligned with the sustainable development goals of nations and their representatives, such as fighting climate change and promoting clean energy, it is also necessary for civil society to be involved in the debate on tax reforms and TRs in the energy sector. To this end, this study seeks to show evidence on the magnitude of the effect of tax incentives on the performance of the energy sector.

3. DATA AND ESTIMATION TECHNIQUES

3.1. Data

To estimate the effects of taxation and TRs on the product of the Peruvian energy industry, economic activities directly related to energy were selected, particularly the production and refining of hydrocarbons and the generation of electricity. The analysis covers the period from January 2010 to December 2023. The period of analysis was chosen on the basis of the availability of data and in order to avoid the external shocks of the 2008 crisis and its consequences. The frequency of the data is monthly and the approach used is time series.

The economic effect of taxation and refunds on the energy sector has been little studied. Most studies on the effects of tax taxation on output address the issue at an aggregate national level, without considering the specific effects on particular sectors and industries. In this work, data from the National Superintendence of Customs and Tax Administration (SUNAT) of Peru are used to obtain information at the industrial level.[5] With this, we can obtain information on TRs and taxation specifically for sectors directly related to energy production.

The main dependent variable in this work, the economic activity of the energy industry, has as a proxy the gross product of the Peruvian energy industry constructed from data from the Central Reserve Bank of Peru (CRBP). The GDP of the energy industry breaks down the contribution of different subsectors within the industry, such as electricity generation, natural resource extraction, energy transportation and distribution, refining, among others. It can show whether the energy industry is expanding, contracting, or staying stable, providing valuable insights into the health and dynamics of this specific sector. In addition, the GDP of the energy industry can be used as an indicator of economic and social development in the country. Solid growth in this sector can indicate an increase in infrastructure, investment and the availability of energy resources, which in turn can boost development in other sectors of the economy and improve the well-being of the population.

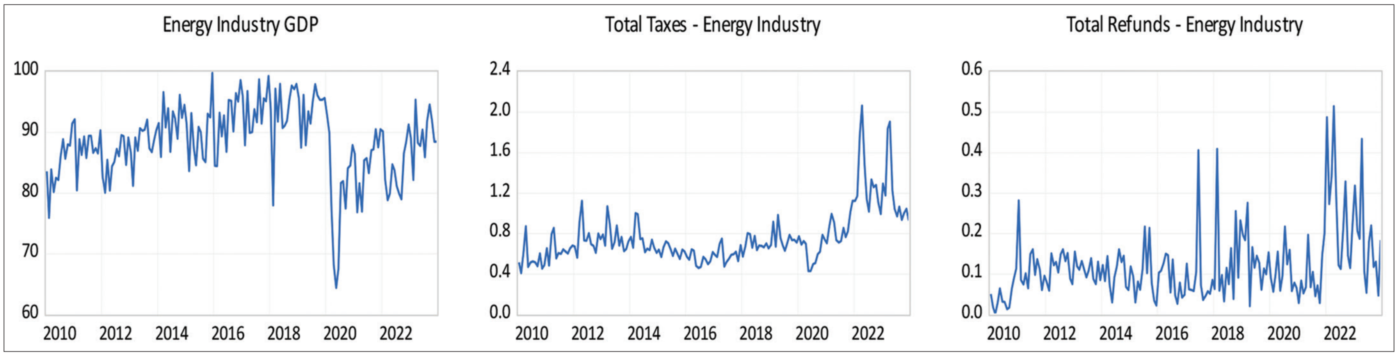
Figure 1 shows the behavior of the main variables of interest. Some interesting details can be gleaned from these charts. First, there is a clear change in behavior in the energy sector GDP series from March 2020 to the end of the time series. This behavior is generated by the crisis caused by the Coronavirus SARS COVID-2. Taxation, on the other hand, shows a growth trend throughout the period, with a significant acceleration from 2020 onwards. At the same time, TRs have remained stable for most of the period and show a significant increase from January 2022 onwards.[6]

To measure the effect and economic impact that taxation and refunds had on the output of the energy sector in Peru, a set of macroeconomic and demographic variables was selected. First, the variable Monetary Policy Reference Interest Rate validates the results found in the literature that interest rates can asymmetrically affect different economic sectors. At the same time, the international oil price and exchange rate variables allow us to verify whether the increase in costs and prices can affect the competitiveness of the energy sector in Peru. Finally, we use future expectations of GDP to reflect how predictions can influence production decisions in this economic sector in Peru.[7]

In this work, information was obtained from 2 different sources. As shown in Table 1, data on energy industry GDP and macroeconomic controls were obtained from the CRBP; In turn,

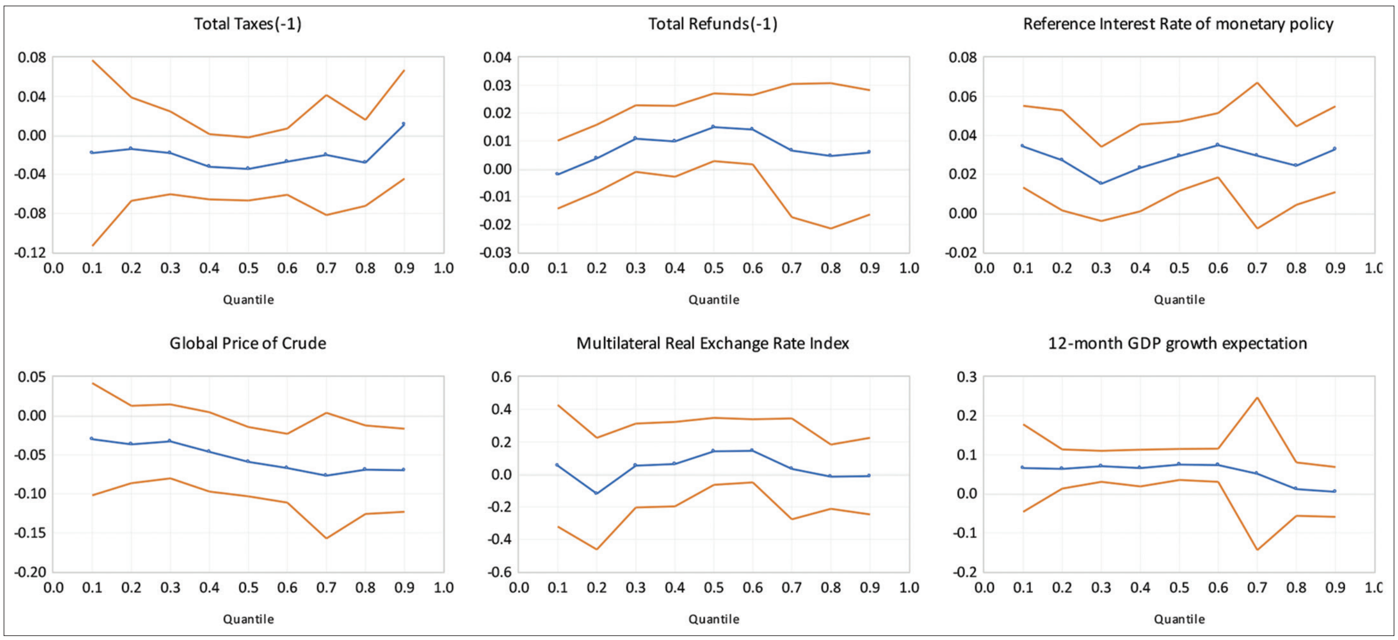
5. Peru's National Superintendence of Customs and Tax Administration (SUNAT) collects a wide range of data related to taxation and refunds for the energy sectors. Some of the specific types of data that can be obtained from SUNAT include:
Tax returns: SUNAT collects data on tax returns filed by companies and taxpayers in the energy sector. This data may include detailed information on the taxes paid, such as Income Tax, General Sales Tax (IGV), and other specific taxes related to energy activity.
Tax refunds: SUNAT records requests and processing of tax refunds submitted by companies and taxpayers in the energy sector. This data can provide information on the amount of returns requested and granted, as well as the timelines and procedures for processing them.
6. Considering that the measures to contain Covid-19 clearly generated effects on production, the models of this work must contemplate a control for the pandemic.
7. All variables were calculated or generated in real terms.

Figure 1: Variables of interest – gross domestic product, taxes and tax refunds of the energy industry in Perú



Source: Authors' own elaboration with data from the SENAT and Central Reserve Bank of Peru. Taxation and Tax Refunds are in the billions of soles

Figure 2: Quantile regression of the effect of the effect of taxation and tax rebates on the gross domestic product of the energy industry



Huber sandwich standard errors and covariance; Sparsity method: Kernel (Epanechnikov) using residuals; Bandwidth method: Hall-Sheather, bw=0.17608

Table 1: Descriptive statistics and source of variables

Stats	Source	Mean	Median	Maximum	Minimum	Standard deviation
Energy industry GDP	CRBP	408	421	481	271	49
Total taxes (energy sector)*	SUNAT	714	654	2070	388	266
Total taxes less refunds (energy sector)*	SUNAT	601	551	1650	112	231
Total refunds (energy sector)*	SUNAT	113	95	514	1	85
Reference interest rate of monetary policy	CRBP	4	4	8	0	2
Global price of crude	CRBP	78	75	134	27	25
Multilateral real exchange rate index	CRBP	9	98	117	90	5
12-month GDP growth expectation	CRBP	5	4	9	−3	2

CRBP: Central Reserve Bank of Peru, SUNAT: National Superintendency of Customs and Tax Administration, GDP: Gross domestic product. *Billion of Soles

taxes and TRs are obtained from the SUNAT. Table 1 also shows information on the descriptive statistics of the variables used in the study, which allow for a better interpretation of the results and magnitudes of the effects found.

3.2. Model Specification

The empirical strategy of this work was divided into two parts. Initially, the effect of net taxation, i.e. TT minus TRs, on the GDP of the energy industry is assessed. In this first model, it is expected to reach results that are compatible with the economic literature, which in turn has shown that a high tax burden can have negative effects on investment, innovation and production within the energy sector, as it reduces the profit margins of firms and decreases their ability to reinvest in productive activities (Price et al., 2005; Metcalf, 2010; Pizer and Sexton, 2019). With this, the model seeks to determine whether there is a significant association between the net taxes paid by companies in the energy sector (*TTLR*) and the total production of goods and services within the industry (*EGDP*).

The results of this model could provide insights into how taxation affects economic activity in the energy sector.[8]

Subsequently, the effects are disaggregated and two exogenous variables of interest are used instead of one: TT, for which a negative effect is expected, and TR, for which positive effects are expected. On the one hand, fiscal taxation, such as income taxes, value-added taxes or taxes specific to the energy sector, can increase the operating costs of companies in the sector, reduce their profit margins and decrease their investment capacity. This can negatively affect the competitiveness of the sector and discourage investment in new technologies or expansion projects. On the other hand, TR can act as a financial stimulus for businesses, providing tax relief and improving their liquidity. This can incentivize investment, innovation, and growth within the energy industry, while improving its ability to comply with fiscal and financial regulations.

In summary, our models are as follows:

$$EGDP_t = \alpha_0 + \alpha_1 EGDP_{t-1} + \alpha_2 TTLR_t + \alpha_3 X_{t,i} + \varepsilon_t \quad (1)$$

$$EGDP_t = \beta_0 + \beta_1 EGDP_{t-1} + \beta_2 TT_t + \beta_3 TR_t + \beta_4 X_{t,i} + \mu_t \quad (2)$$

Where ε_t and $\mu_t \sim N(0, \sigma^2)$ y X_t and Y_t are the vectors of independent control variables.

Control variables capture macroeconomic elements that influence industrial performance. Specifically, they are:

Autoregressive Component of Energy Industry GDP and Energy Industry GDP Growth Expectations - According to theories such as rational expectations (Lovell, 1986) and adaptive expectations (Evans and Ramey, 2006) and research such as that of Mincer and Zarnowitz (1969), lagging economic indicators and economic growth expectations can be important predictors of future growth in a specific sector. Such as the energy industry. In this sense, an energy industry GDP out of step in an earlier period can reflect past industry conditions and provide insights into its dynamics and trends over time. On the other hand, 12-month GDP growth expectations can represent economic agents' perspectives on the future of the economy and energy demand. As these measures increase, the GDP of the energy industry tends to improve for several reasons. First, a positive lagging GDP indicates past growth in industry, which can spur investment and expansion in the present. In addition, 12-month GDP growth expectations can build confidence among investors and entrepreneurs, which can increase investment in energy projects and infrastructure development.

Monetary Policy Benchmark Interest Rate – In the context of the energy industry, the benchmark interest rate can affect GDP in a number of ways. First, an increase in the benchmark interest rate tends to make credit more expensive and reduce the availability of financing for investment projects in the energy industry. However, in developing countries, as the benchmark interest rate rises, a contraction in aggregate demand and a reduction in inflation may also occur, leading to tighter monetary policy. In this context, tighter monetary policy can help stabilize inflation expectations and improve business and investor confidence in the economy, which in turn can stimulate investment and economic growth in the energy industry (Wright, 2002). In addition, an increase in the benchmark interest rate can strengthen the national currency and reduce dependence on energy imports, which can improve the competitiveness of the energy industry and promote its long-term growth (Lee and Werner, 2018; Keams and Manners, 2018).

International oil price - When the price of oil increases, this can have adverse effects on the GDP of the energy industry for several fundamental reasons. First, an increase in the price of oil tends to increase production costs in the energy industry, as higher crude oil prices translate into higher expenses to extract, refine, and transport oil. This increased pressure on costs can reduce profit margins and decrease the profitability of companies in the energy sector. In addition, an increase in the price of oil can lead to a decrease in demand for energy products, as consumers and businesses may look for cheaper alternatives or implement energy efficiency measures to reduce their dependence on oil. This can result in a drop in the production and sales of energy products, which in turn negatively affects the GDP of the energy industry. These relationships have been extensively documented in the academic literature. For example, a study by Jiménez-Rodríguez and Sánchez (2005) found that increases in the price of oil were associated with a decrease in industrial production in oil-importing countries. In addition, research such as that of Kilian (2009) has shown that increases in the price of oil can have contractionary effects on overall economic activity, including production and growth in the energy industry.

Multilateral exchange rate - According to studies such as that of Bahmani-Oskooee and Hajilee (2010), movements in the multilateral exchange rate can have significant effects on various economic sectors, including the energy industry. In the case of the energy industry, an increase in the multilateral exchange rate can have beneficial effects on GDP for several reasons. First, a strengthening of the national currency can reduce the cost of imports of equipment and technologies used in the energy industry, which can increase efficiency and reduce production costs. On the other hand, an increase in the multilateral exchange rate can make domestic energy products more competitive in international markets, which can boost exports and increase industry revenues and reduce energy imports from abroad.

Equations (1) and (2) are estimated using ordinary least squares (OLS) and GMM using the Newey-West Matrix (HAC) to avoid problems arising from autocorrelation or heteroscedasticity.[9] Initially, all the variables are used in their level form, but estimates are also made with the variables in their logarithmic form in order to obtain

8. Several academic papers have suggested that the way taxes on the energy industry are structured, such as tax incentives for exploration and production, can influence companies' decision-making and resource allocation in the sector.

9 The Newey-West matrix is essential in the analysis of time-series COD regressions because it corrects for autocorrelation and heteroscedasticity problems, ensures consistency and efficiency of estimates, and enables reliable hypothesis testing. Its use is essential to obtain valid and robust results when working with time series data in econometrics.

Table 2: Unit root test

Variable	ADF			PP		
	Lag	Prob.	Max Lag	Prob.	Bandwidth	CV (10%) MZt
Energy industry GDP	12	0.9148	14	0.865	66	−1.6
Total taxes (energy sector)	14	0.7920	14	0.370	29	−1.6
Total taxes less refunds (energy sector)	13	0.8832	14	0.067	59	−1.6
Total refunds (energy sector)	7	0.3237	14	0.000	8	−1.6
Reference interest rate of monetary policy	1	0.3485	14	0.511	10	−1.6
Global price of crude	1	0.3953	14	0.472	3	−1.6
Multilateral real exchange rate index	1	0.5433	14	0.562	5	−1.6
12-month GDP growth expectation	3	0.1141	14	0.134	6	−1.6

Akaike and Schwarz information criteria were used to determine the exogenous terms of the test equation (intercept only - I or trend and intercept - I+T), when tied, the Hannan-Quinn criterion was used as the deciding vote

the elasticities and effects with direct interpretations.[10] To check if the series has unit root, we performed the Fisher (ADF) and Philips-Perron (PP) unit root tests which can be found in the Table 2 below.

The results indicate that all series exhibit an integration behavior of order one (I(1)). The usual thing in such cases would be to use differentiated series to make the estimates; However, this strategy could result in the loss of relevant information about the long-term relationship between the variables. This is because the results of the Johansen test reveal that the series are cointegrated, and since we have a limited number of observations, it is crucial to consider this long-term relationship. To avoid this problem, Hamilton's (2020) recommendation is followed and models with series at the level are estimated.

For the GMM models, we use as instruments the variables of the model with an offset of up to 4 periods and an external control that captures the period of the crisis generated by COVID-19. In addition, we evaluated these models using the J-Statistic and D-W-H (Durbin-Wu-Hausman) tests. First, the J-Statistic test is used to evaluate the validity of the GMM model specification. This test verifies whether the theoretical moments and empirical moments match, which is essential to ensure that the model is correctly specified and that the estimated parameters are consistent and efficient. On the other hand, the D-W-H test is crucial to examine the presence of serial correlation in the residues of the GMM model. Autocorrelation in residuals can indicate that the model does not adequately capture the temporal dynamics of the data, which could lead to biased or inefficient estimates of parameters. Therefore, performing this test is crucial to ensure the reliability of the model's estimates.

Finally, the Wald test of parameter equality is used to determine whether the parameter representing the positive effect of TR is able to compensate for the negative effect of tax payments. The Wald test of parameter equality is used to evaluate whether two coefficients estimated in a regression model are statistically equal to each other. To carry out this test, the regression model must first be estimated, which includes both variables: TR and TT. After obtaining the estimated coefficients and their respective standard errors, the Wald test statistic is calculated using the following formula:

$$W = \frac{\left(\beta_2 - \beta_3\right)^2}{Var\left(\beta_2\right) + Var\left(\beta_3\right)}$$

Where:
β_2 is the estimated coefficient for taxation.
β_3 is the estimated coefficient for TR.
Var (β_2) and *Var* (β_3) are the estimated variances of the respective coefficients.

If the results of the Wald test of parameter equality indicate that TR are statistically equal to tax payments, this would suggest that refunds could indeed offset some of the regressive effects of TT on the GDP of the energy industry. This conclusion would have important implications for policymakers, as it would provide them with a potential strategy to counteract the negative effects of taxation on the economic growth of the energy sector.

4. EMPIRICAL RESULTS

To assess the impacts of net taxation on the GDP of the energy industry in Peru, Table 1 presents the estimates obtained using the OLS and General Moments of Moments (GMM) methods for Equation (1). First, the P-values associated with the F-statistic of both models are remarkably low, close to zero, suggesting high statistical significance and a substantially better fit than that of a model without explanatory variables. In addition, the P-values of the Lagrange Multiplier Test are relatively small, indicating significant evidence of serial autocorrelation in the model residuals. Likewise, the P-values of the Autoregressive conditional heteroskedasticity (ARCH) test are also low, suggesting the presence of conditional heteroscedasticity in the model residuals. Together, these results support the application of Newey-West matrix correction in estimates, which strengthens the robustness of our model against possible autocorrelations and heteroscedasticities in errors.

In relation to GMM estimates, the results of the statistical tests reaffirm those already found and bring new relevant information. The J statistic is used to evaluate the validity of the instrumental moments used in the GMM model and is calculated as the product of the moment vector and the inverse of the weighting matrix. The P-value (J-stat) indicates the statistical significance of the J-statistic, which in this case is 0.753 and 0.564 for the level and logarithmic model, respectively. Since the P-value is greater than

10 The logarithmic transformation of the variables makes the relationship between them more linear. This can be beneficial for capturing complex relationships between variables and reducing bias in estimated coefficients. In addition, in many cases, logarithmic transformation of variables can help reduce heteroscedasticity in residuals, i.e., the variability of errors is not constant across the values of the independent variable. This improves the accuracy of the estimators and makes the confidence intervals more reliable.

the significance level, 0.05, the null hypothesis that instrumental moments are correctly specified is accepted. On the other hand, the P-value of the statistical significance of the D-W-H test, being higher than the significance level 0.05, suggests that there is no evidence of serial correlation in the residuals and the results are even more robust than those found in OLS.

The OLS and GMM regressions highlight essential connections between the explanatory variables and the output of the energy industry. The negative and significant relationship between net tax taxation on the energy industry and the GDP of this same industry is a fundamental result in this paper and needs to be carefully explained. First, an increase in the tax burden on energy companies can have an adverse impact on their profitability and competitiveness, which in turn can discourage investment and expansion in the sector. This situation could lead to a reduction in production and economic activity within the energy industry, manifesting as a decrease in its GDP. In addition, previous research such as that of Garcia-Mila and McGuire (2001) and Goulder (1994) has suggested that an excessive tax burden can have negative effects on the economic growth of highly capital-intensive sectors, such as the energy industry. These studies support the idea that heavier taxation could hinder the economic performance of the energy industry, which would be consistent with the negative relationship observed between net tax taxation and GDP of this sector in your research.

The GMM model on the logarithmic basis indicates that a 1% increase in net taxation is associated with a 0.02% contraction in the GDP of the energy industry.[11] While this effect may seem small, in the long run it can have a significant impact on the growth of the sector. The robustness of the result has been verified by performing different sensitivity tests. The results are kept consistent using different control variables, estimation methods, and model specifications. However, it is important to note that the magnitude of this effect is relatively small compared to the total size of the energy industry's GDP. This could indicate that while taxation can influence the economic performance of the sector, there are other factors and dynamics that also play an important role in determining growth and production in the energy industry. A summary of these results is presented in Table 3 below.

Table 3: OLS and GMM estimates of the effect of net taxation on the gross domestic product of the energy industry

DV: Energy Industry GDP	Equation 1		
Regressors	OLS	GMM	GMM log
C	44.192***	13.332*	2.073**
	(67.496)	(37.753)	(0.991)
Energy Industry GDP (-1)	0.498***	0.812***	0.744***
	(0.077)	(0.063)	(0.116)
Total Taxes less Refunds	−0.003*	−0.003*	−0.024*
	(0.009)	(0.009)	(0.014)
IR	0.969**	0.424*	0.009
	(1.888)	(1.086)	(0.007)
GPC	−0.043**	−0.001*	−0.017*
	(0.085)	(0.058)	(0.017)
ER	−0.001	0.043	−0.019
	(0.494)	(0.252)	(0.080)
GDP EXPCT	0.592*	0.159	0.019*
	(1.733)	(0.827)	(0.020)
Adj. R2	0.423	0.339	0.392
F-stat	19.632		
P-value (F-stat)	0.000		
LM test	4.011		
Prob (LM)	0.018		
ARCH test	4.489		
Prob (ARCH)	0.036		
J-statistic		11.866	13.491
P-value (J-stat)		0.753	0.564
D-W-H test		7.148	8.520
P-value (D-W-H)		0.307	0.289
N. Instr./N. Obs.		23/168	23/168

Levels of significance: ***denotes 0.01, **denotes 0.05 and *denotes 0.1. Standard errors in parentheses. OLS equation based on Newey and West (1987) estimators. ARCH: Autoregressive conditional heteroskedasticity

The autoregressive factor of the GDP of the energy industry, out of phase in one period, exhibits a positive and significant coefficient in relation to the explanation of the GDP of this same industry. This feature highlights the importance of considering the past behavior of energy GDP when modeling its current dynamics. The positivity of the autoregressive coefficient suggests that previous trends in energy GDP growth have a persistent impact on its current behavior. This finding is consistent with academic literature highlighting the presence of economic inertia in the energy industry, where patterns of growth and decline tend to persist over time due to the nature of long-term investments and the physical infrastructure required. In addition, these results indicate that econometric models that incorporate the history of energy GDP can more effectively capture the underlying dynamic relationships in the industry, thus providing a better understanding of its behavior and facilitating the formulation of appropriate policies and strategies for its sustainable development.

The coefficient of the monetary policy reference interest rate is revealed to be positive and highly significant in its ability to explain the GDP of the energy industry. This result is supported by the economic literature, which has examined the relationship between monetary policy and the performance of different economic sectors. For example, research such as that of Wright (2002) and Driffill et al. (2006) shows that an increase in interest rates can help maintain financial stability by discouraging excessive borrowing and reducing the risks of speculative bubbles. This can contribute to greater financial strength and resilience in businesses and households that consume energy products, which in turn promotes a more stable environment for investment and long-term growth. In addition, according to the Kearns and Manners (2018) study, a higher interest rate environment can make financial assets denominated in the domestic currency more attractive to foreign investors, which can boost the inflow of foreign capital into the energy industry. This can facilitate the financing of energy infrastructure projects and encourage the transfer of technology and knowledge in the sector, thus contributing to the development and modernisation of the industry.

The international oil price coefficient exhibits a negative and statistically significant relationship with the explanation of

11. In a log-log regression, both the dependent variable and the independent variables are transformed by the natural logarithm. The interpretation of the coefficients in this type of regression is done in terms of elasticities.

the GDP of the energy industry. This relationship reflects the sensitivity of economic activity in the energy sector to fluctuations in international oil prices, a phenomenon widely documented in the economic literature. The negative relationship suggests that an increase in the price of oil tends to reduce the GDP of the energy industry, while a decrease in oil prices can have the opposite effect. This dynamic can be explained by several mechanisms. For example, an increase in oil prices can increase production costs and input prices in the energy industry, which can reduce the profitability of companies and discourage investment and expansion in the sector. In addition, higher oil prices can increase energy costs for consumers and businesses, which can reduce demand for energy products and services and ultimately negatively impact economic activity in the industry.

The multilateral exchange rate shows a negative relationship with the explanation of the GDP of the energy industry, although it does not reach statistical significance. This relationship indicates that variations in the multilateral exchange rate may have some influence on the economic performance of the energy industry, but this influence is not robust enough to be considered statistically significant in this specific context. The lack of statistical significance could be attributed to several factors, such as the presence of other more important determinants of the energy industry's GDP that are being captured in the model, such as the international price of oil, which already has a major impact on the exchange rate itself.

The coefficient of GDP growth expectations is presented as positive and statistically significant in most specifications, suggesting a positive impact on the GDP explanation of the energy industry. This finding reflects the importance of economic expectations for the performance of the energy industry, and finds support in the economic literature that has examined the relationship between growth expectations and economic activity in different sectors. For example, studies such as Eusepi and Preston (2011) have highlighted how growth expectations can influence investment and spending decisions in firms and consumers, which in turn can have significant effects on production and employment in sectors such as energy. In the specific context of the energy industry, GDP growth expectations may be particularly relevant due to their impact on energy demand, energy product prices, and investment decisions in energy infrastructure projects.

Table 4 presents in detail the results obtained from the estimates for equation (2). At this stage of the analysis, we have broken down the effect of net taxation into two distinct variables: Tax taxation and TR. This approach allows for a deeper understanding of how each component of net taxation influences the phenomenon studied. By disaggregating these variables, we can more accurately identify the specific impact of tax taxation and TR on the desired outcome, in this case, the GDP of the energy industry. This detailed analysis allows us not only to assess the magnitude and direction of the effect of each tax component, but also to better understand the underlying mechanisms driving the relationships observed in our econometric model.

The findings derived from the regression reveal a significant picture of the relationship between tax taxation, TR and the GDP of the energy industry.[12] First, the coefficient associated with fiscal taxation exhibits a significant negative relationship with the GDP of the energy sector. This result suggests that an increase in the tax burden on energy companies is linked to a decrease in economic activity in this sector. This negative relationship can be attributed to a variety of factors, such as the direct impact of higher taxes on companies' profit margins, which can reduce their ability to invest and expand. In addition, an increase in taxation may influence the final prices of energy products, which could affect demand and ultimately the growth of the sector. On the other hand, it is observed that the coefficient associated with TR is positive and statistically significant in most estimates to explain the GDP of the energy industry. This result suggests that TR act as a positive stimulus for economic activity in the energy sector. TR can function as financial incentives for businesses, easing the tax burden and providing additional resources that can be reinvested in productive activities. This finding reinforces the importance of fiscal policies that promote efficient and effective returns, as they can play a crucial role in fostering growth and competitiveness in the energy industry.

Table 4: OLS and GMM estimates of the effect of taxation and tax rebates on the gross domestic product of the energy industry

DV: Energy industry GDP	Equation 2		
Regressors	OLS	GMM	GMM log
C	44.212***	12.744	1.367**
	(14.130)	(8.306)	(0.715)
Energy Industry GDP (-1)	0.498***	0.824***	0.749***
	(0.077)	(0.060)	(0.095)
Total Taxes	−0.003*	−0.005**	−0.056***
	(0.000)	(0.000)	(0.021)
Refunds	0.004	0.018*	0.029**
	(0.000)	(0.000)	(0.014)
IR	0.968**	0.339*	0.009*
	(0.390)	(0.205)	(0.006)
GPC	−0.043**	−0.012	−0.015
	(0.017)	(0.989)	(0.006)
ER	−0.001	0.012	0.079
	(0.104)	(0.062)	(0.073)
GDP EXPCT	0.593	0.214	0.028*
	(0.379)	(0.189)	(0.073)
Adj. R2	0.423	0.302	0.359
F-stat	16.723		
P-value (F-stat)	0.000		
LM test	3.999		
Prob (LM)	0.018		
ARCH test	4.453		
Prob (ARCH)	0.036		
J-statistic		16.405	15.464
P-value (J-stat)		0.630	0.693
D-W-H test		5.958	8.907
P-value (D-W-H)		0.545	0.259
No. Instr./No. Obs.		0.160	0.161
Ho: a3+a4=0	0.016	1.395	3.314
Wald - *P* value (F)	0.987	0.165	0.071

Levels of significance: *** denotes 0.01, ** denotes 0.05 and * denotes 0.1. Standard errors in parentheses. OLS equation based on Newey and West (1987) estimators. ARCH: Autoregressive conditional heteroskedasticity

12. As the results for the other control variables do not vary significantly and were already explained in the interpretation of Table 3, we do not dwell on them again and focus on the variables of interest.

The Wald parameter equality test indicates that TR have the potential to equal in magnitude to the effect of taxation on the GDP of the energy industry (Wald - P-value (F) >0.05). The equality in magnitude between TR and taxation may also indicate a trade-off relationship between these two factors. In other words, the results of the test suggest that TR have the potential to mitigate the adverse effects of tax taxation on the GDP of the energy industry. This trade-off ratio highlights the importance of a balanced approach in fiscal policymaking, where TR can play a crucial role in promoting economic growth and competitiveness in the energy sector.

As an extra exercise, the equations were reestimated from a quantile regression model to understand whether the effects of taxation and TR were greater in magnitude when the GDP of the energy industry already presented a previous trend.[13] The results indicate that this is not the case. Both TT and TR have their full effects when the GDP of the energy industry is at medium levels (quartiles 0.4–0.6) and fail to reverse its trend when GDP is already at high levels (quartiles +0.6) or low levels (quartiles −0.4). For example, the effectiveness of tax rebates in stimulating the GDP of the energy industry is lower when the economy is operating well below its optimal level and when it is operating at potential GDP; On the other hand, when growth is moderate, tax rebates are effective in raising the GDP of the energy industry.

The findings of the quantile regression analysis in Figure 2, highlight the nuanced relationship between fiscal policies and the performance of the energy industry under different economic conditions. Specifically, the results indicate that the impact of taxes and TR on industry production varies depending on the prevailing state of the energy market. In periods characterized by sustained and historically average GDP growth, both higher taxes and lower TR appear to hamper industry growth, reflecting greater sensitivity to fiscal measures when economic conditions are normal. Conversely, during phases of solid economic expansion or huge contraction, the energy sector shows resilience to changes in fiscal policy, suggesting that other factors may exert a greater influence on its performance during these periods.

In addition, the results underscore the importance of adopting adaptive fiscal policies that align with the energy industry's business cycle. Policymakers should prioritise the implementation of measures tailored to the specific needs and challenges faced by the sector, especially during periods of moderate growth. During such phases, TR may have a more pronounced effect on stimulating the industry's GDP, implying that targeted interventions aimed at optimising the efficiency and effectiveness of TR mechanisms could generate significant benefits for the energy sector. By aligning fiscal policy with the cyclical dynamics of the industry, policymakers can improve the resilience of the sector and contribute to its long-term growth and sustainability.

13. The results of a quantile regression plot provide information about how the effect of independent variables varies in different quantiles of the dependent variable. Each line in the graph represents the estimate of the coefficient of an independent variable in a specific quantile of the distribution of the dependent variable. If the slope of a line is positive, it indicates that the effect of the independent variable is greater on that quantile compared to lower quantiles. On the other hand, if the slope is negative, it means that the effect of the independent variable is smaller in that quantile.

5. CONCLUDING REMARKS

This paper presents a rigorous analysis of the impact of taxation and TR on the GDP of the energy industry in Peru. This study is based on a sound empirical approach and presents a rigorous methodology. A comprehensive collection of relevant data related to taxation and TR in the energy sector was carried out. Subsequently, these data were subjected to a thorough statistical analysis, allowing an accurate assessment of the complex and dynamic relationships that exist between the GDP of the energy industry and the independent variables of greatest interest.

Statistical analyses on the impact of taxation and TR on the Peruvian energy industry lead to the conclusion that these fiscal policies play a significant role in the economic dynamics of this sector. The results of the econometric estimates reveal a negative and statistically significant relationship between net fiscal taxation and the GDP of the energy industry, suggesting that an increase in the tax burden may lead to a contraction in economic activity in this area. On the other hand, it is observed that TR have a positive and significant impact on the GDP of the energy industry, highlighting its ability to stimulate economic activity and mitigate the adverse effects of tax taxation.

This study not only provides a comprehensive analysis of fiscal policies and their impact on the Peruvian energy industry, but also highlights the importance of considering the sector-specific economic context when designing policy strategies. The research highlights the need for balanced fiscal policies that not only seek to maximize tax revenues, but also stimulate economic growth in a sustainable manner. In addition, it points out the relevance of adapting these policies to the fluctuations of the energy industry's economic cycle, highlighting the importance of periods of moderate growth where TR can have a greater impact on stimulating the sector. Additional analyses using quantile regression models indicate that both tax and TR have more pronounced effects on GDP growth in the energy industry when it is at medium levels of economic activity. These results underscore the importance of implementing fiscal policies that are sensitive to the energy industry's business cycle, focusing on periods of moderate growth where tax returns may have a greater impact on stimulating the sector.

In summary, this study provides empirical evidence supporting the importance of fiscal policies in the Peruvian energy industry. The findings highlight the need to design balanced fiscal policies that optimize both tax revenues and economic stimuli to ensure sustainable development in this crucial sector of the Peruvian economy. In addition, they suggest the relevance of considering the specific economic context of the energy industry when formulating fiscal policies, in order to maximize their effectiveness and promote solid and sustainable economic growth in the long term.

The significant contribution of this study lies in its ability to provide valuable and evidence-based information, offering a more complete understanding of how TR can significantly impact the performance of the energy industry, to the point of rivaling in magnitude with

Table 5: A research agenda for future studies

No.	Method	Dependent variables	Independent variables	Research proposal
1	Survival analysis	Duration of energy companies in the market	Tax taxation, tax returns, company size, market competition, government regulations	Study of the duration of energy companies in the Peruvian market
2	Analysis of differences in differences	Economic activity in the energy sector	Tax refunds, government policies, investment in energy infrastructure, macroeconomic indicators	Assessing the effectiveness of tax refunds in the energy sector
3	Autoregressive vector models (VARs)	Tax revenues, economic activity in the energy sector	Oil prices, exchange rates, energy market volatility, fiscal policies, economic expectations	Analysis of the impact of energy market volatility on fiscal policies
4	OLS, GMM	Investment in Renewable and Non-Renewable Energy	Taxes on coal; emissions taxes; tax refunds for good environmental practices; marketing controls	Evaluate how taxation on gas emissions and incentives for renewable energy production affect investment in types of energy

Own elaboration based on the research findings

tax taxation, which can be useful for both policymaking and future research in this field. Consequently, in the Table 5 below we formulate possible studies derived from this work and its methods of analysis and measurement. For example, the proposed survival analysis could shed light on the duration and stability of energy companies in the Peruvian market, providing valuable insights into the factors influencing their permanence and success. In addition, the difference-in-differences approach could help assess the effectiveness of TR in stimulating economic activity in the energy sector, providing important insights for policymaking. In addition, the use of autoregressive vector models (VARs) could allow for a more detailed analysis of the impact of energy market volatility on the country's fiscal and economic policies, providing crucial information for risk management and strategic planning. Finally, the use of regression methods such as OLS and GMM to study the relationship between taxation and investment in renewable and non-renewable energy could provide a comprehensive view of how fiscal policies can influence the transition to more sustainable energy sources. These research proposals open up new perspectives for future studies that could further enrich our understanding of the economic dynamics in the Peruvian energy sector.

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