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Sectoral Trends in Final Energy Consumption in the Philippines: A Regression Analysis Using PSA Data

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ABSTRACT

Energy consumption is a crucial driver of economic growth and sustainability, particularly in developing nations such as the Philippines. This study examines sectoral trends in final energy consumption from 2014 to 2022 using econometric analysis, specifically multiple linear regression, to assess the influence of sector classification and temporal factors on energy demand. Secondary data from the Philippine Statistics Authority (PSA) were analyzed, focusing on key sectors: transport, industry, households, services, and agriculture. Descriptive statistics and regression modeling were applied to identify sector-specific energy consumption patterns and evaluate their predictive significance. The results indicate that sector classification significantly influences energy consumption, with the transport sector exhibiting the highest demand, followed by households and industry. In contrast, year alone was not a statistically significant predictor, suggesting that energy demand is primarily driven by sectoral activity rather than a simple time-based trend. While the regression model demonstrated strong explanatory power ($R^2 = 0.65$), issues such as heteroskedasticity and autocorrelation were detected, underscoring the need for advanced econometric techniques to improve model precision. This study highlights the importance of sector-specific energy policies in achieving sustainability and optimizing resource allocation. Policymakers should develop targeted interventions that address the unique energy demands of each sector. Future research should refine statistical approaches, incorporate broader economic and environmental variables, and explore advanced modeling techniques to enhance the accuracy and applicability of energy policy frameworks.

Keywords: Energy Demand, Sustainability, Econometric Modeling, Regression Analysis, Resource Allocation, Policy Intervention

1. INTRODUCTION

1.1 Rationale

Energy consumption is a key determinant of economic growth, technological advancement, and societal development. Nations with increasing energy demands must carefully balance industrial expansion, household consumption, and environmental sustainability. As economies transition toward modernization, understanding sectoral energy consumption trends becomes critical for policymakers, businesses, and energy providers to ensure efficient energy distribution and long-term sustainability. In the Philippines, a rapidly developing economy, energy consumption has grown significantly over the past decades due to urbanization, industrialization, and increased mobility. However, limited studies have provided a sector-specific quantitative analysis of historical trends and future projections, which is essential for informed energy policymaking (Asuamah et al., 2013, and Fernandes &; Reddy, 2020).

Final energy consumption, which refers to the total energy directly used by end consumers across different sectors, serves as an essential metric for assessing energy demand and efficiency (Wan et al., 2020). In the Philippines, the transport sector is historically the largest energy consumer, primarily due to the heavy reliance on fossil fuels for road transport, aviation, and shipping. The household sector is another major contributor, influenced by population growth, lifestyle changes, and access to electricity. Meanwhile, the industrial sector consumes substantial energy for manufacturing and production, but shifts toward automation and energy efficiency measures have influenced its consumption patterns. The agriculture and services sectors, while smaller in total energy demand, play crucial roles in national energy consumption due to mechanization and increasing commercial activities (Ludovice & Delina, 2023). Despite the availability of official statistics from the Philippine Statistics Authority (PSA), there has been no comprehensive study that quantifies and models these trends over time using econometric methods such as regression analysis.

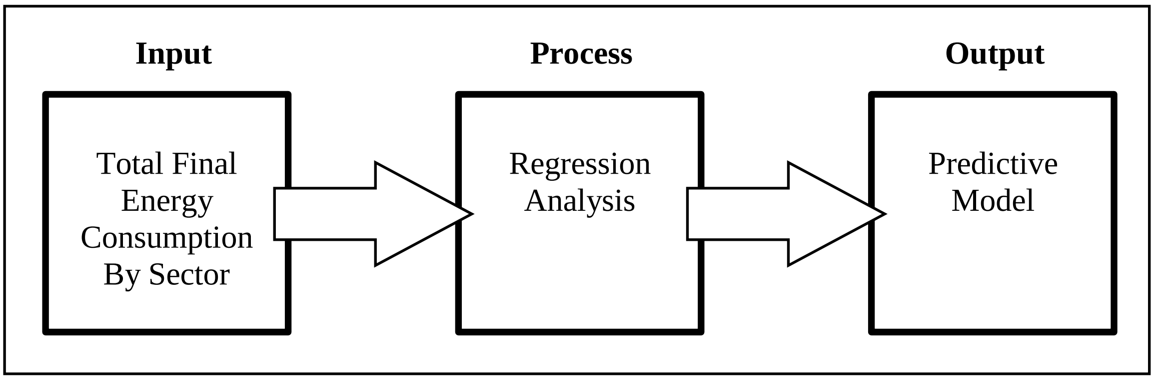
While several global studies have investigated the link between energy consumption and economic development, research focusing on sector-specific energy trends in the Philippine context remains scarce (Parreño, 2022). Existing reports and academic literature have primarily focused on macro-level energy consumption and electricity generation, often overlooking disaggregated sectoral data. Moreover, prior studies have largely relied on descriptive statistics without utilizing predictive modeling techniques, such as regression analysis, to estimate sectoral growth trends and forecast future demand. This gap in empirical analysis limits the ability of policymakers and stakeholders to develop targeted energy strategies that align with long-term economic and environmental goals.

Additionally, with emerging challenges such as climate change policies, the transition to renewable energy, and the increasing adoption of energy-efficient technologies, understanding the rate at which each sector's energy demand is evolving is critical. Without such insights, energy planning may remain reactive rather than proactive, leading to inefficient resource allocation and potential energy shortages in the future. By addressing this gap, this study aims to provide data-driven insights that can guide national energy policies, infrastructure development, and sustainability initiatives.

1.2 Conceptual Framework

This study examines the sectoral trends in final energy consumption in the Philippines using historical data recorded by the Philippine Statistics Authority (PSA) from 2014 to 2022. The framework consists of three main components: Input, Process, and Output.

Figure 1. Conceptual Framework



The input of this study comprises the total final energy consumption by sector over a nine-year period. This dataset includes disaggregated consumption figures from key sectors such as transport, industry, households, services, and agriculture. By analyzing these sector-specific trends, the study aims to provide insights into the evolving energy demands of the country.

The process involves a systematic approach to data analysis, beginning with descriptive statistics to summarize sectoral energy consumption patterns. This includes computing measures of central tendency (mean), dispersion (standard deviation, minimum and maximum), and trend analysis over time. Next, the study ensures the validity of regression modeling by checking key statistical assumptions, such as normality, linearity, homoscedasticity, and multicollinearity. Once assumptions are verified, correlation analysis is performed to assess the strength of the relationship between time (years) and sectoral energy consumption. If a significant correlation is found, the study proceeds with Ordinary Least Squares (OLS) regression analysis, estimating the annual growth rate of energy consumption per sector. To ensure the accuracy of the predictive model, model validation techniques such as R^2 (coefficient of determination), residual analysis, and goodness-of-fit tests are employed.

The output of this study is a predictive model that estimates future energy consumption trends for each sector. This model provides sector-specific growth rate estimates and forecasts energy demand for the period 2023–2027. By offering empirical insights into sectoral energy consumption, the findings of this study will support policy formulation, resource allocation, and sustainable energy planning in the Philippines. Ultimately, the predictive model serves as a data-driven tool to aid government agencies, energy providers, and researchers in making informed decisions regarding national energy strategies.

1.3 Analytical Framework

The analytical framework establishes the methodology used to assess the relationship between total final energy consumption and sector-specific energy consumption as independent variables. This study employs the Multiple Linear Regression (MLR) Model, which is suitable for estimating the extent to which each sector influences total energy consumption while controlling for variations over time. The MLR model is particularly appropriate given the structure of the dataset, which consists of cross-sectional data observed over multiple years (2014–2022).

The regression model is formulated as follows:

Figure 2. *Regression Model*

$$\boldsymbol{E = \beta_0 + \beta_1 Year + \beta_2 Sector + \varepsilon}$$

where:

- E represents the final energy consumption of a sector at a given time.
- β_0 is the intercept, representing the baseline level of energy consumption when all other factors are zero.
- β_1, β_2 are the regression coefficients that quantify the effects of the independent variables on total energy consumption.
- $Year$ is continuous variable representing the observation period, capturing trends in energy consumption over time.
- $Sector$ is a categorical variable that distinguishes among industry, transportation, households, services, agriculture, and non-energy use, allowing for sectoral differentiation in energy consumption patterns.
- ε is the random error term accounting for variability not explained by the model.

The analytical framework ensures a rigorous quantitative assessment of energy consumption patterns across sectors. By utilizing MLR, the study aims to identify statistically significant relationships between energy consumption and sectoral classifications while considering temporal trends. The results will provide empirical insights into sector-specific energy demand, facilitating informed decision-making for energy policy, resource management, and sustainability planning in the Philippines.

1.4 Statement of Objective

This study aims to analyze total final energy consumption trends in the Philippines from 2014 to 2022, with a focus on sectoral differences and key influencing factors. Specifically, it seeks to:

1. Examine the trends in total final energy consumption across different sectors (industry, transportation, households, services, agriculture, and non-energy use) over the nine-year period (2014–2022) using descriptive statistics and trend analysis.
2. Identify the significant predictors of total final energy consumption by assessing the statistical significance of sector classification and year in the regression model.
3. Validate the regression model by testing key assumptions, including linearity, independence of residuals, homoscedasticity, multicollinearity, and normality of residuals, to ensure the reliability and robustness of the findings.
4. Provide empirical insights into energy consumption dynamics that can inform energy policies, sectoral planning, and sustainability strategies in the Philippines.

1.5 Scope and Delimitation

This study examines total final energy consumption in the Philippines by analyzing sectoral trends using Multiple Linear Regression (MLR). Specifically, it investigates how sector classification and time (year) influence energy consumption patterns across key sectors, including industry, transportation, households, services, agriculture, and non-energy use. The study utilizes secondary data from the Philippine Statistics Authority (PSA) covering the period 2014 to 2022, providing a longitudinal perspective on energy consumption trends. The findings aim to generate empirical insights that contribute to energy policy discussions, infrastructure planning, and sustainable resource management in the country.

However, the study is subject to several delimitations. It focuses solely on sectoral classification and time as independent variables and does not incorporate other potential drivers of energy consumption, such as economic growth, population dynamics, technological advancements, or environmental policies. Additionally, macroeconomic factors—including global energy price fluctuations, government regulations, and climate change-related impacts—are beyond the scope of this analysis and are not directly accounted for in the regression model.

Another key delimitation is the timeframe of the dataset, which is restricted to 2014 to 2022. As a result, longer-term historical trends and recent developments beyond this period are not included in the analysis. Furthermore, the study does not establish causal relationships between the variables, as correlation and regression analysis only indicate statistical associations. The predictive model generated is based on historical trends, meaning its applicability to future energy consumption patterns is subject to external influences not captured within the dataset. Despite these limitations, the study provides a data-driven approach to understanding sector-specific energy demand, which can inform policy decisions, investment strategies, and future research on energy consumption trends in the Philippines.

2. METHODOLOGY

Research Design

This study employs a quantitative research design utilizing multiple linear regression (MLR) analysis to examine sectoral trends in total final energy consumption in the Philippines. The MLR model is used to evaluate the relationship between total energy consumption (dependent variable) and multiple independent variables, including sector classification and time (year). This approach is appropriate for understanding variations in energy consumption patterns across sectors and identifying statistically significant trends over time.

MLR is well-suited for this study as it allows for the simultaneous analysis of multiple independent variables, enabling the assessment of how different economic sectors contribute to overall energy demand while controlling for time-related variations. By applying this statistical technique, the study aims to quantify the effects of sectoral classifications on energy consumption, offering an evidence-based framework for interpreting long-term consumption patterns. To ensure the validity and reliability of the results, key assumptions of MLR—including linearity, independence of residuals, homoscedasticity, and normality—will be tested. Additionally, statistical significance testing will be conducted to determine the extent to which each sector influences total energy consumption.

Through the application of multiple linear regression, this study seeks to generate data-driven insights that can inform energy policymakers, industry stakeholders, and sustainability planners about sector-specific energy demands. The findings will contribute to discussions on energy efficiency, resource allocation, and long-term sustainability strategies in the Philippines.

Research Locale

This study focuses on the Philippines, utilizing nationwide secondary data on total final energy consumption from the Philippine Statistics Authority (PSA). The dataset covers multiple economic sectors, including industry, transportation, households, services, agriculture, and non-energy use, allowing for a comprehensive analysis of sector-specific energy consumption trends. By examining energy consumption at the national level, the study aims to provide insights into macro-level energy demand patterns, which are crucial for policy formulation, resource allocation, and sustainability planning.

The study is anchored in the context of key Philippine energy policies that influence national energy consumption and sustainability efforts. The Philippine Energy Plan (PEP) serves as a long-term roadmap set by the Department of Energy (DOE) to ensure energy security, affordability, and sustainability, emphasizing efficient energy use and the integration of renewable energy sources. Additionally, the Renewable Energy Act of 2008 (Republic Act No. 9513) promotes the development, utilization, and commercialization of renewable energy technologies to reduce dependence on fossil fuels. Another significant policy, the Energy Efficiency and Conservation Act (Republic Act No. 11285), institutionalizes energy efficiency measures across various sectors to optimize energy use and minimize waste. Furthermore, the Electric Power Industry Reform Act (EPIRA) of 2001 (Republic Act No. 9136) restructures the electricity sector to promote competition and ensure the affordability of power supply. Complementing these initiatives, the National Renewable Energy Program (NREP) outlines a strategic framework for increasing the share of renewable energy in the country's energy mix, supporting the transition toward sustainable energy.

By situating the study within the framework of these policies, the research contributes to the ongoing discourse on energy efficiency, sustainability, and the optimization of energy resources in the Philippines. The findings are expected to provide empirical insights that can guide policymakers, industry leaders, and energy planners in shaping data-driven strategies for sustainable energy consumption.

Figure 3 presents the Map of the Asia – Highlighting Philippines to provide a clearer geographical context for the locale of the study.

Figure 3. Map of the Asia – Highlighting Philippines

Source: Tropical Experience Travel Services - Tours of the Philippines https://encr.pw/hLwxo

As an archipelagic country in Southeast Asia, the Philippines consists of 7,641 islands, with diverse geographical and economic landscapes that influence energy consumption patterns. The country's energy sector is shaped by its growing population, industrialization, transportation infrastructure, and reliance on both conventional and renewable energy sources.

Located in the Pacific Ring of Fire, the Philippines faces unique energy challenges, including high vulnerability to natural disasters that impact energy supply and distribution. Additionally, as a developing economy, the country's energy demand is influenced by rapid urbanization, economic expansion, and government initiatives aimed at energy sustainability. Luzon, home to the capital Metro Manila, serves as the economic and industrial hub, accounting for the highest energy demand, while Visayas and Mindanao have distinct consumption patterns based on regional economic activities.

Understanding the geographical and economic landscape of the Philippines is crucial in analyzing sectoral energy consumption trends. This study aims to provide empirical insights that contribute to national energy policy discussions and the development of strategies for efficient and sustainable energy use.

Data Source

This study exclusively utilized secondary data, eliminating the need for primary data collection. The dataset was obtained from the Philippine Statistics Authority (PSA) OpenSTAT database (https://encr.pw/EFt8o), an official government portal that provides public access to statistical data on various economic, social, and environmental indicators. The PSA is the national statistical agency of the Philippines, ensuring that the data used in this study adheres to established standards of accuracy, reliability, and consistency.

The dataset includes records on total final energy consumption by sector, covering the period from 2014 to 2022. This comprehensive timeframe allows for the identification of historical trends, sectoral variations, and potential predictive patterns in energy consumption across different industries. Given that the data is collected and maintained by the PSA, it provides a credible basis for analysis, ensuring that the study's findings are grounded in official national statistics.

By relying on verified secondary data, this study contributes to the existing body of research on energy consumption trends in the Philippines, offering insights that may support policy formulation, energy planning, and sustainability initiatives.

Data Gathering Procedure

The researcher accessed and retrieved the total final energy consumption data from the Philippine Statistics Authority (PSA) OpenSTAT portal. The dataset covered a nine-year period (2014–2022) and included key variables such as year (time effect), sector classification (e.g., industry, transportation, households, services, agriculture, and non-energy use), and total final energy consumption (measured in thousand tons of oil equivalent (kTOE)).

Since the study relied on secondary data, no direct interaction with respondents was required. To ensure data integrity and consistency, the researcher evaluated the dataset for completeness and accuracy before proceeding with analysis. As the dataset was publicly available through an open government data portal, its use complied with data privacy regulations and ethical standards for research.

After extraction, the dataset was systematically coded using Table 1, the Data Coding Matrix for Sector, to facilitate statistical analysis. This structured approach ensured uniformity in variable classification and accuracy in subsequent computations, supporting the development of a predictive model based on sectoral energy consumption trends.

Table 1. Data Coding Matrix for Sector

Attribute	Code
Industry	5
Transport	4
Households	3
Services	2
Agriculture	1
Non-Energy Use	0

Statistical Data Treatment

The statistical analysis in this study followed a structured approach to address the research objectives using Multiple Linear Regression (MLR) in Jamovi, an open-source statistical software. The analysis included trend examination, regression modeling, and assumption testing to ensure the validity and reliability of the findings.

Descriptive Analysis of Final Energy Consumption By Sector

To analyze final energy consumption by sector (industry, transportation, households, services, agriculture, and non-energy use) across different years, trend analyses were conducted to identify patterns and disparities over time. Descriptive statistics such as mean, standard deviation, minimum, and maximum values were computed to summarize sectoral energy consumption. Additionally, line graphs were generated to illustrate energy consumption trends over the nine-year period (2014–2022), allowing for a visual representation of fluctuations and long-term changes in sectoral energy usage. A scatter plot was also utilized to examine the overall trend of energy consumption over time, providing an initial assessment of whether total final energy consumption followed a linear, exponential, or irregular trend. These visualizations helped determine consumption patterns and potential variations across different sectors.

Regression Analysis of the Effects of Year and Sector Classification on Total Final Energy Consumption

To identify the key predictors of total final energy consumption variations, a Multiple Linear Regression (MLR) model was developed, with year and sector classification as independent variables. This method quantified the relationship between these factors and total final energy consumption, providing coefficient estimates to indicate the extent to which each predictor influenced energy consumption.

Hypothesis testing was performed using p-values and confidence intervals, where a statistically significant p-value ($p < .05$) indicated that the predictor had a meaningful effect on energy consumption. The regression equation was then used to interpret how each additional year and sector classification contributed to total final energy consumption trends. This analysis helped identify systematic disparities in energy consumption among different sectors, allowing for a data-driven understanding of energy usage patterns.

Validating the Regression Model

To ensure the reliability of the regression analysis, the study assessed key statistical assumptions necessary for Multiple Linear Regression:

i. Linearity: The relationship between the independent variables and wage rates will be examined using scatter plots and residual plots to confirm a linear trend rather than a non-linear one.

ii. Independence of Residuals: The Durbin-Watson test will be conducted to check for autocorrelation, ensuring that wage rates in one period will not systematically affect those in another.

iii. Homoscedasticity: The variance of residuals will be evaluated through residual scatter plots to verify that it remained constant across different wage levels. If heteroscedasticity (non-constant variance) is detected, necessary transformations or robust standard errors will be considered.

iv. Multicollinearity: The Variance Inflation Factor (VIF) will be calculated to detect potential correlations among independent variables. If VIF values exceeded acceptable thresholds (e.g., VIF > 10), adjustments such as variable removal or data transformation will be considered.

v. Normality of Residuals: The Shapiro-Wilk test and Q-Q plots will be used to determine whether residuals followed a normal distribution, which is crucial for accurate hypothesis testing.

Finally, the overall model significance was assessed using the F-test, and the R-squared and adjusted R-squared values were examined to evaluate how well the model explained variations in total final energy consumption. By systematically conducting these analyses, the study ensured that its findings were statistically sound, reliable, and meaningful, providing empirical insights into total final energy consumption trends. These insights could serve as a basis for informing energy policies and sustainability strategies in the Philippines.

4. RESULTS AND DISCUSSION

Section 1. Descriptive Analysis of Final Energy Consumption By Sector

Table 2 presents a summary of final energy consumption by sector from 2014 to 2021, illustrating variations in energy demand across different industries.

Table 2. Descriptive Analysis of Final Energy Consumption By Sector

					Shapiro-Wilk	
Sector	Mean	SD	Min	Max	*W*	*p*
Industry	7083	516.1	6336	7925	0.976	0.942
Transport	11221	1208.4	9133	12697	0.947	0.658
Households	9456	647.5	8488	10310	0.953	0.726
Services	4283	595.6	3370	4936	0.870	0.123
Agriculture	445	64.2	354	556	0.974	0.925
Non-Energy Use	1285	307.7	605	1642	0.890	0.198

The transport sector recorded the highest mean energy consumption (M = 11,221 kTOE, SD = 1,208.4), indicating consistently high energy demand. This sector also exhibited the greatest variability, as reflected in its standard deviation, suggesting fluctuations in energy usage over time.

The household sector ranked second in energy consumption (M = 9,456 kTOE, SD = 647.5), followed by the industrial sector (M = 7,083 kTOE, SD = 516.1). These results highlight the substantial contribution of residential and industrial activities to national energy consumption.

Conversely, the agriculture sector had the lowest mean energy consumption (M = 445 kTOE, SD = 64.2), reflecting its relatively minimal energy demand compared to other sectors. The non-energy use sector, which includes energy used for non-fuel purposes such as chemical feedstocks, had a mean energy consumption of 1,285 kTOE (SD = 307.7).

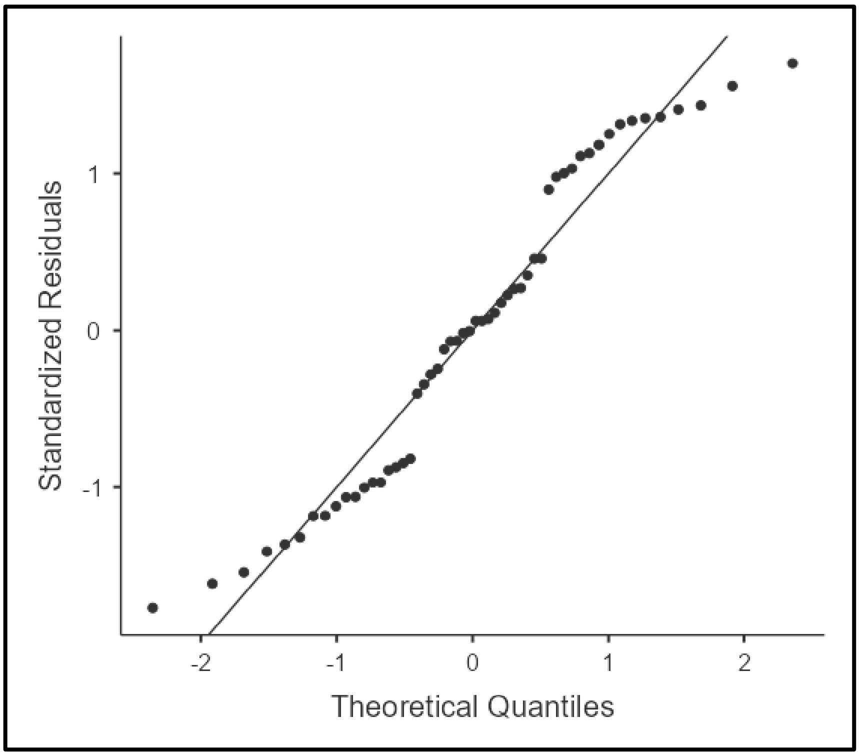
The services sector exhibited moderate energy consumption (M = 4,283 kTOE, SD = 595.6), with values ranging from 3,370 to 4,936 kTOE, suggesting a stable yet fluctuating trend over the years.

Results from the Shapiro-Wilk test indicate that energy consumption data for all sectors followed a roughly normal distribution ($p > .05$), except for the services sector ($p = .123$) and non-energy use sector ($p = .198$), which exhibited slight deviations from normality.

Overall, these findings suggest substantial sectoral differences in energy consumption, with transportation and household activities being the most energy-intensive, while agriculture remains the least energy-demanding. This analysis provides a foundation for further exploration of the factors driving sectoral energy consumption in the Philippines.

Figure 4 presents the Q-Q plot, which visually assesses the normality of residuals in the regression analysis. The data points in each subplot closely follow the 45-degree reference line, indicating that the residuals are approximately normally distributed. Although minor deviations are observed at the tails, suggesting slight skewness, these deviations are not severe enough to indicate a significant violation of the normality assumption.

Figure 4. Q-Q Plot



Furthermore, the Shapiro-Wilk test results presented in Table 2 confirm that the residuals do not significantly deviate from normality ($p > .05$ for all sectors). Given this statistical evidence, the assumption of normality is reasonably met, supporting the validity of the regression analysis.

Section 2. Regression Analysis of the Effects of Year and Sector Classification on Total Final Energy Consumption

Table 3 presents the correlation analysis between total final energy consumption and the independent variables: year and sector classification.

Table 3. Correlation Between Total Final Energy Consumption, Year, and Sector Classification

Variables	df	Pearson's r	p-value	Inference
Energy Consumption Year	52	0.072	0.606	Retain H_o
Energy Consumption Sector	52	0.803	<.001	Reject H_o

The correlation between energy consumption and year yielded a Pearson's r of 0.072 with a p-value of 0.606, indicating no significant linear relationship between energy consumption and time. This suggests that total final energy consumption did not exhibit a strong increasing or decreasing trend over the nine-year period.

Conversely, the correlation between energy consumption and sector classification was strong and significant ($r = 0.803$, $p < .001$). This result suggests that sector classification has a strong influence on energy consumption patterns, with different sectors demonstrating distinct levels of energy usage. Given this significant relationship, further analysis through multiple linear regression is warranted to quantify the specific effects of each sector on total final energy consumption.

Table 4 presents the regression model assessing the relationship between final energy consumption, sector classification, and year demonstrated a strong model fit.

Table 4. Model Fit Measures

R	R^2	Adj. R^2	F	df1	df2	p
0.806	0.650	0.637	47.4	2	51	<.001

As shown in Table 4, the multiple correlation coefficient (R) was 0.806, indicating a strong positive relationship between the predictors and total final energy consumption. The coefficient of determination (R^2) was 0.650, suggesting that 65.0% of the variance in final energy consumption was explained by the model. The adjusted R^2 value of 0.637 accounts for the number of predictors, confirming that the model remains a strong fit even after adjusting for potential overfitting. The F-test yielded a statistically significant result, $F(2, 51) = 47.4$, $p < .001$, indicating that the overall model significantly predicts energy consumption.

Table 5. Model Coefficients

Predictor	Estimate	SE	t	p
Intercept	-225837	261420	-0.864	0.392
Sector	1900	196	9.7	<.001
Year	112	130	0.867	0.39

Based on the coefficients reported in Table 5, the estimated regression equation for total final energy consumption (E) is:

$$E = -225837 + 1900 \times Year + 112 \times Sector$$

where:

- Intercept (-225,837, p = .392): Represents the expected energy consumption when both sector classification and year are zero. However, this value is not meaningful in the real-world context, as negative energy consumption is not possible.
- Sector (1,900, $p < .001$): Indicates that for each increase in sector classification (i.e., moving from one sector to the next), energy consumption increases by an average of 1,900 kTOE. This effect is statistically significant ($p < .001$), suggesting that sector classification plays a crucial role in determining energy consumption.
- Year (112, p = .390): Suggests that each additional year contributes to an increase of 112 kTOE in total energy consumption. However, this effect is not statistically significant (p = .390), indicating that year alone does not have a strong independent impact on energy consumption after accounting for sector classification.

The findings suggest that sector classification is a significant determinant of total final energy consumption, while the effect of year is not statistically significant. This implies that energy consumption patterns are primarily driven by sector-specific demand rather than simply increasing over time. The strong model fit and significant sector coefficient highlight the importance of understanding sector-based energy consumption trends when formulating energy policies. Future research may explore interaction effects or incorporate additional variables to refine the predictive power of the model further.

Section 3. Validating the Regression Model

To ensure the validity of the regression model, several diagnostic tests were conducted to assess normality, heteroskedasticity, autocorrelation, and multicollinearity. The results are summarized in Tables 6 to 9.

Table 6. Normality Test

Test Statistic	Statistic	p
Shapiro-Wilk	0.944	0.013
Kolmogorov-Smirnov	0.127	0.320

Anderson-Darling	0.952	0.015

Note. Additional results provided by moretests

Table 6 presents the results of normality tests, including Shapiro-Wilk, Kolmogorov-Smirnov, and Anderson-Darling tests. The Shapiro-Wilk test (W = 0.944, p = .013) and Anderson-Darling test (A = 0.952, p = .015) both yielded statistically significant results, suggesting that the residuals deviate from normality. However, the Kolmogorov-Smirnov test (D = 0.127, p = .32) did not indicate a significant deviation. Given the conflicting results, it is possible that the residuals exhibit minor deviations from normality, but they may still be approximately normal for large sample sizes due to the central limit theorem.

Table 7. Heteroskedasticity Tests

Test Statistic	Statistic	p
Breusch-Pagan	28.4	<.001
Goldfeld-Quandt	0.535	0.934
Harrison-McCabe	0.823	1

Note. Additional results provided by moretests

Table 7 presents the results of heteroskedasticity tests. The Breusch-Pagan test yielded a significant result ($\chi^2 = 28.4$, $p < .001$), indicating the presence of heteroskedasticity, meaning that the variance of residuals is not constant across different levels of the predictors. However, the Goldfeld-Quandt test (GQ = 0.535, p = .934) and Harrison-McCabe test (HM = 0.823, p = 1) were both non-significant, suggesting no clear evidence of heteroskedasticity under these alternative testing methods. The significant Breusch-Pagan test result suggests that robust standard errors or transformation techniques may be necessary to correct for heteroskedasticity.

Table 8. Durbin–Watson Test for Autocorrelation

Autocorrelation	DW Statistic	p
0.867	0.229	<.001

The Durbin-Watson test (Table 8) assessed the presence of autocorrelation in the residuals. The DW statistic of 0.867 with a highly significant p-value ($p < .001$) suggests positive autocorrelation in the residuals. This implies that consecutive residuals are correlated, violating the assumption of independence. Corrective measures, such as adding lagged predictors or using generalized least squares, may be necessary to address this issue.

Table 9. Collinearity Statistics

Predictor	VIF	Tolerance
Sector	1	1
Year	1	1

Table 9 presents Variance Inflation Factor (VIF) and Tolerance values to assess multicollinearity. Both predictors (Sector and Year) had VIF = 1 and Tolerance = 1, indicating no multicollinearity in the model. This suggests that the independent variables are not highly correlated and that the regression estimates remain stable.

The diagnostic tests suggest that while the regression model is generally appropriate, violations in normality, heteroskedasticity, and autocorrelation require further attention. The non-normality of residuals may suggest the need for a data transformation or bootstrapping techniques. The heteroskedasticity detected in the Breusch-Pagan test suggests that robust standard errors should be considered to obtain more reliable statistical inferences. Finally, autocorrelation in residuals indicates that future models may need to incorporate time-series corrections, such as ARIMA modeling or the inclusion of lag variables. Despite these concerns, the absence of multicollinearity suggests that the model coefficients remain interpretable.

Section 4. Empirical Insights and Policy Implications on Energy Consumption Dynamics in the Philippines

The findings of this study provide key empirical insights that can inform energy policies, sectoral planning, and sustainability strategies in the Philippines. The analysis revealed significant sectoral disparities in energy consumption, with the transport sector emerging as the highest energy consumer, followed by households and industry, while the agriculture sector had the lowest energy demand. These results highlight the need for sector-specific energy policies. For the transport sector, policies should focus on fuel efficiency improvements, electric vehicle incentives, and public transportation enhancements to reduce fossil fuel dependency. In the household sector, energy efficiency programs such as incentives for energy-saving appliances and solar panel adoption could help reduce residential energy demand. Meanwhile, in the industrial sector, the promotion of cleaner and more efficient energy sources, including natural gas and renewables, is essential for long-term sustainability.

The regression analysis further suggested that sector classification significantly predicts energy consumption, while year alone does not. This indicates that energy consumption is primarily driven by sectoral energy demand rather than time-related factors alone. As a result, energy policies should focus on sector-specific demand trends rather than relying solely on broad, time-based energy forecasts. Future projections must also incorporate sectoral growth patterns rather than assuming a uniform increase in energy demand over time.

Despite the study's strong predictive findings, some statistical limitations were observed, particularly heteroskedasticity and autocorrelation issues, which may affect the accuracy of predictions. However, these limitations do not invalidate the results but rather highlight the need for more refined econometric models, such as time-series corrections or panel regression adjustments, in future research. Additionally, further studies should explore additional variables, including energy prices, policy changes, and technological advancements, to enhance the predictive power of the model.

Based on these findings, several policy recommendations can be made to improve energy efficiency and sustainability. First, sector-based energy diversification should be prioritized to reduce dependency on fossil fuels by integrating renewable energy sources into the transport and industrial sectors. Second, energy efficiency programs should be implemented, such as green building standards, appliance efficiency labeling, and industry energy audits, to optimize energy consumption. Finally, data-driven energy planning should be adopted, where policymakers leverage sector-specific data analytics to ensure precise forecasting and resource allocation.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

The findings of this study provide empirical insights into the patterns and determinants of final energy consumption across various sectors in the Philippines. The analysis revealed that sector classification is a significant predictor of energy consumption, with the transport sector exhibiting the highest energy demand, followed by households and industry, while agriculture had the lowest energy consumption. The regression results indicate that sectoral demand primarily drives energy usage, whereas year alone does not have a statistically significant effect, highlighting the importance of sector-specific energy policies rather than generalized, time-based interventions.

Although the regression model demonstrated strong explanatory power ($R^2 = 0.65$), some statistical limitations were identified, including heteroskedasticity and autocorrelation, which may affect the precision of predictions. However, these issues do not invalidate the findings but rather suggest the need for advanced econometric techniques, such as panel data regression or time-series modeling, to enhance the robustness of future analyses.

This study underscores the critical role of sectoral energy consumption patterns in informing energy policies and sustainability strategies in the Philippines. By leveraging these insights, policymakers can design targeted interventions to optimize energy use, reduce environmental impact, and enhance national energy security. Future research should refine statistical models to improve predictive accuracy and incorporate broader economic and environmental variables to develop a more comprehensive and data-driven energy policy framework.

4.2 Recommendations

Based on these findings, several recommendations can be proposed to inform energy policy, sectoral planning, and sustainability strategies:

Sector-Specific Energy Policies: Given the high energy demand in the transport sector, fuel efficiency improvements, electric vehicle incentives, and enhanced public transportation infrastructure should be prioritized. The household sector would benefit from energy-saving programs, such as incentives for energy-efficient appliances and renewable energy adoption. In the industrial sector, cleaner production technologies and the integration of renewable energy sources should be promoted.

Energy Diversification and Efficiency Programs: The government should encourage the adoption of renewable energy sources across high-consumption sectors, such as biofuels in transportation and solar energy in residential and commercial buildings. Additionally, energy efficiency measures, such as green building standards, industry energy audits, and appliance efficiency labeling, should be implemented to optimize energy consumption.

Data-Driven Energy Planning: Policymakers should utilize sector-specific data analytics to create more precise energy consumption forecasts and allocate resources efficiently. Future projections should consider sectoral growth trends and technological advancements, rather than relying solely on historical energy consumption patterns.

Further Research and Model Refinements: Future studies should explore additional factors influencing energy consumption, such as energy prices, technological advancements, and policy interventions, to improve the predictive accuracy of econometric models. Moreover, advanced statistical techniques, such as heteroskedasticity-robust regression or machine learning approaches, should be explored to address statistical limitations and enhance model reliability.

In conclusion, this study highlights the critical role of sectoral energy consumption patterns in shaping energy policies and sustainability strategies in the Philippines. By implementing targeted, data-driven energy policies, the government and stakeholders can enhance energy efficiency, promote sustainability, and strengthen national energy security.

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