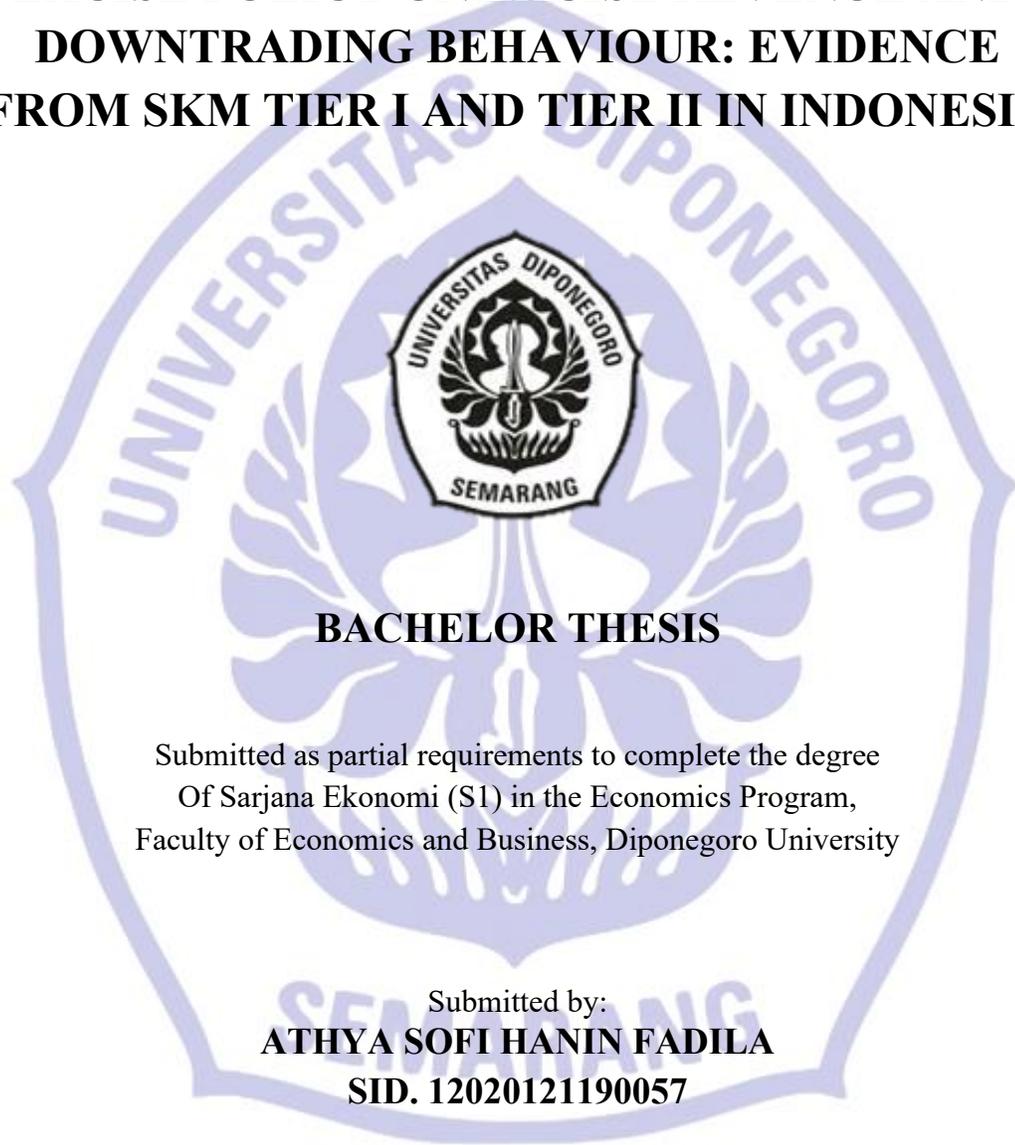


**THE NON-LINEAR IMPACT OF TOBACCO
EXCISE POLICY ON EXCISE REVENUE AND
DOWNTRADING BEHAVIOUR: EVIDENCE
FROM SKM TIER I AND TIER II IN INDONESIA**



BACHELOR THESIS

Submitted as partial requirements to complete the degree
Of Sarjana Ekonomi (S1) in the Economics Program,
Faculty of Economics and Business, Diponegoro University

Submitted by:
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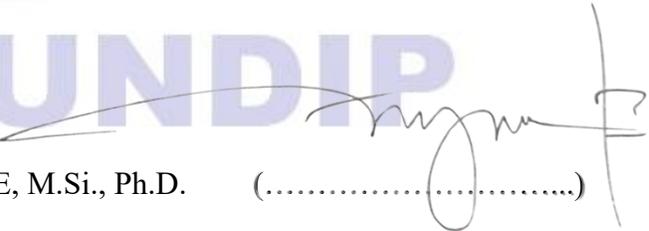
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STATEMENT OF THESIS ORIGINALITY

I, Athya Sofi Hanin Fadila, hereby declare that this study titled **“THE NON-LINEAR IMPACT OF TOBACCO EXCISE POLICY ON EXCISE REVENUE AND DOWNTRADING BEHAVIOUR: EVIDENCE FROM SKM TIER I AND TIER II IN INDONESIA”** is solely my own work. I have clearly referenced, in both the text and the bibliography of references, all sources used in the work. I understand that any false claim and academic misconduct in respect of this work will result in disciplinary action in accordance with university regulations, including revocation of the degree.

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MOTTO AND DEDICATION

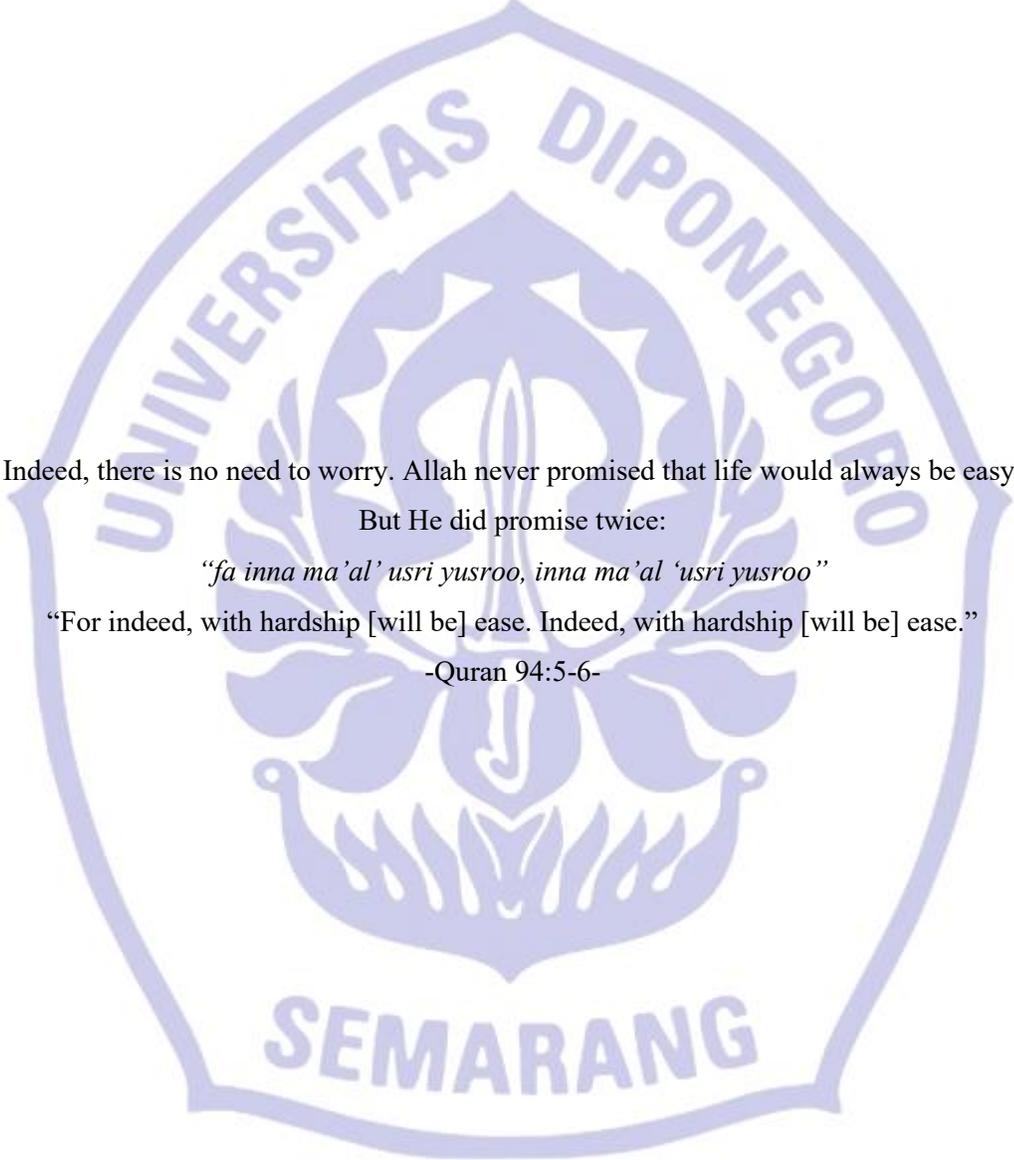
Indeed, there is no need to worry. Allah never promised that life would always be easy.

But He did promise twice:

“fa inna ma’al’ usri yusroo, inna ma’al’ usri yusroo”

“For indeed, with hardship [will be] ease. Indeed, with hardship [will be] ease.”

-Quran 94:5-6-



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I dedicate this thesis to the endless learning journey and to my parents, big brother, family, and friends, whose boundless love, steadfast support, and constant encouragement have guided me every step of the way.

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ABSTRACT

This research analyzes the effectiveness of Indonesia's multi-tier cigarette excise tax policy in responding to the rising phenomenon of downtrading from SKM Tier I to Tier II products, a behavioral shift that increasingly threatens long-term revenue stability. As tobacco excise serve as the backbone of Indonesia's non-tax revenue, contributing more than 95 percent of total national excise receipts, understanding the interaction between tariff adjustments and economic conditions is critical within the framework of public economics and fiscal policy. Using quarterly data from 2017–2024, the research employs an interaction-based Ordinary Least Squares (OLS) model to analyze how GDP at current prices moderates the relationship between tier-specific excise rates and government revenue.

The empirical findings reveal clear asymmetries across tiers. Increases in Tier I excise rates significantly enhance state revenue, consistent with theoretical with the inelastic demand expected for premium cigarette. In contrast, higher Tier II excise rates produce a non-linear or negative revenue effect, reflecting intensified substitution toward cheaper products and confirming the relevance of cross-price elasticities and Laffer-curve dynamics within Indonesia's tiered market. The analysis further demonstrates that higher GDP strengthens the positive revenue impact of Tier I reforms while mitigating the adverse effects associated with Tier II tariffs.

Overall, the study concludes that Indonesia's complex tiered structure amplifies market distortions and limits the government's ability to capture optimal revenue. These results underscore the urgency for greater tariff harmonization and structural simplification to improve revenue performance and align excise policy with broader fiscal objectives.

Keywords: *Tobacco Excise, Downtrading, Multi-Tier Tax Structure, Fiscal Policy, Government Revenue, Laffer Curve.*

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ABSTRAK

Penelitian ini menganalisis efektivitas kebijakan cukai rokok bertingkat di Indonesia dalam merespons meningkatnya downtrading, yaitu pergeseran konsumsi dari produk SKM Tier I ke Tier II yang mengancam stabilitas penerimaan jangka panjang. Mengingat cukai hasil tembakau merupakan tulang punggung penerimaan negara bukan pajak yang menyumbang lebih dari 95 persen dari total penerimaan cukai nasional, pemahaman mengenai interaksi antara penyesuaian tarif dan kondisi ekonomi menjadi krusial dalam kerangka ekonomi publik dan kebijakan fiskal. Menggunakan data triwulan periode 2017–2024, penelitian ini menerapkan model Ordinary Least Squares (OLS) untuk menganalisis bagaimana PDB atas dasar harga berlaku memoderasi hubungan antara tarif cukai per tier dan penerimaan negara.

Temuan empiris menunjukkan adanya asimetri yang jelas antar tingkat. Kenaikan tarif cukai Tier I secara signifikan meningkatkan penerimaan negara, konsisten dengan ekspektasi teoretis mengenai permintaan yang relatif inelastis pada kategori rokok premium. Sebaliknya, peningkatan tarif cukai Tier II menunjukkan dampak non-linear yang mengindikasikan adanya substitusi menuju produk dengan harga lebih rendah, sekaligus menegaskan relevansi elastisitas silang dan dinamika kurva Laffer dalam struktur cukai bertingkat di Indonesia. Analisis moderasi lebih lanjut menunjukkan bahwa kenaikan PDB memperkuat dampak positif reformasi tarif Tier I, sekaligus mengurangi konsekuensi negatif dari kenaikan tarif Tier II.

Secara keseluruhan, penelitian ini menyimpulkan bahwa struktur cukai bertingkat yang kompleks dapat memperbesar distorsi pasar dan membatasi optimalisasi penerimaan negara. Hasil ini menegaskan urgensi harmonisasi tarif dan penyederhanaan struktur cukai guna menelaraskan kebijakan cukai dengan tujuan fiskal nasional.

Kata Kunci: *Cukai Hasil Tembakau, Downtrading, Struktur Cukai Bertingkat, Kebijakan Fiskal, Penerimaan Negara, Kurva Laffer.*

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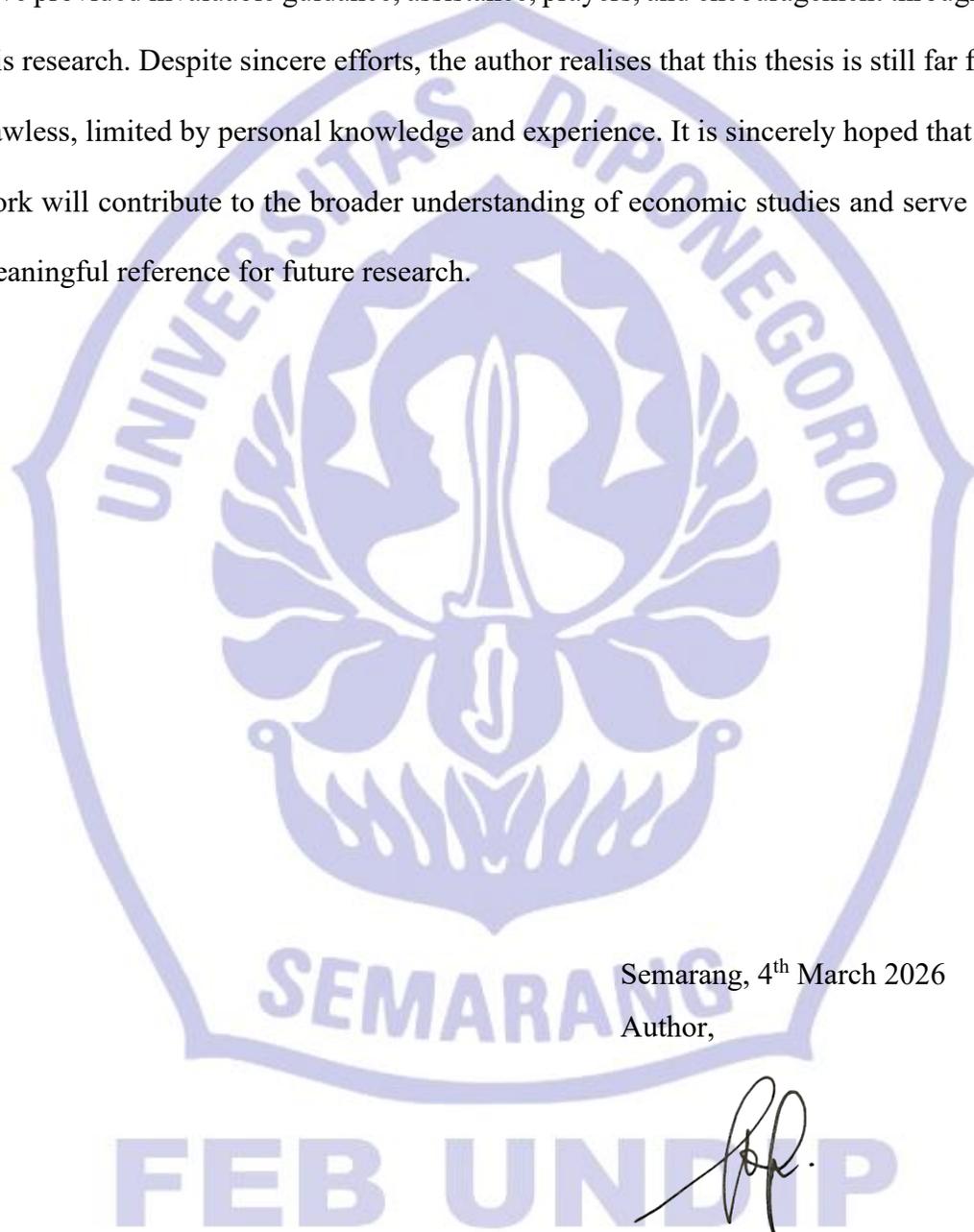
All praise is due to Gusti Allah, whose mercy and grace have enabled me to complete this thesis entitled “**The Non-Linear Impact of Tobacco Excise Policy on Excise Revenue and Downtrading Behaviour: Evidence from SKM Tier I and Tier II in Indonesia**”. There were moments when the complexity of the work felt overwhelming, times when the author felt deeply inspired by the power of economic thought, and other times when motivation seemed to fade. Yet, through each obstacle and breakthrough, the author gained a stronger appreciation for the analytical rigour of economics and the determination needed to navigate its intellectual demands. This thesis is dedicated to those who have been a constant source of support, insight, and encouragement throughout this academic endeavour:

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2. Prof. Akhmad Syakir Kurnia, S.E., M.Si., Ph.D., as Head of the Economics Department, Faculty of Economics and Business, Diponegoro University.
3. Dr. Jaka Aminata, S.E., M.A., as the Head of the Study Program of Economics Studies and the author’s academic advisor, Faculty of Economics and Business, Diponegoro University.
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With deepest gratitude, the author prays that Allah SWT may bless all those who have provided invaluable guidance, assistance, prayers, and encouragement throughout this research. Despite sincere efforts, the author realises that this thesis is still far from flawless, limited by personal knowledge and experience. It is sincerely hoped that this work will contribute to the broader understanding of economic studies and serve as a meaningful reference for future research.



Semarang, 4th March 2026

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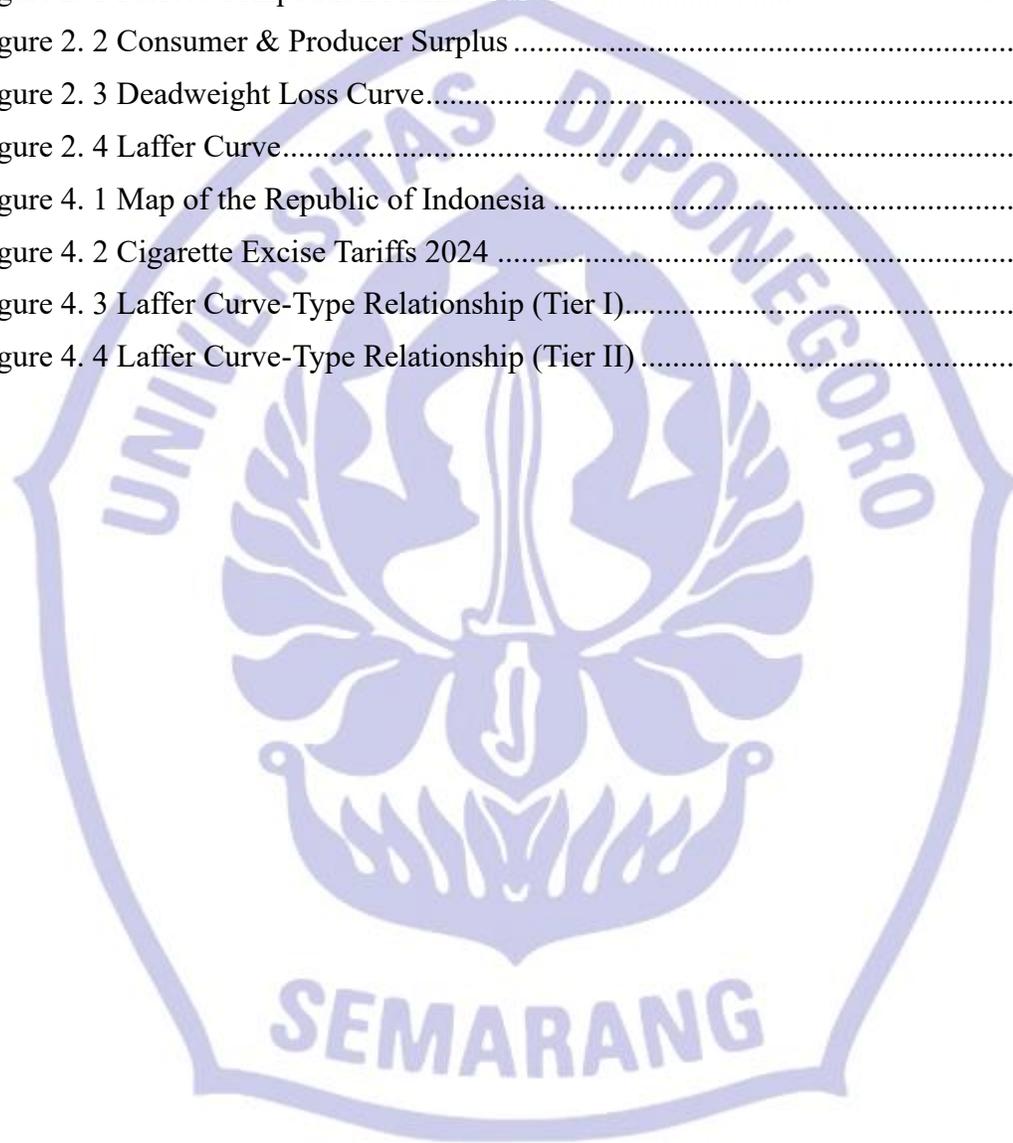
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CHAPTER I

INTRODUCTION

1.1. Background

The Tobacco Industry plays a crucial and irreplaceable role as the backbone of state revenue through excise instruments. Tobacco Excise (*Cukai Hasil Tembakau*) consistently dominates the national revenue structure, accounting for an average of more than 95% of total excise revenue. Based on Table 1.1, this dominance is reflected in the 2023 realisation data, where of the total excise revenue of IDR217.99 trillion, IDR213.49 trillion or around 97.93% came from Tobacco Excise. This very large and stable proportion shows the government's fiscal dependence on the tobacco sector, placing the Tobacco Excise policy in a permanent dilemma between its budgetary function (collecting state revenue) and its regulatory function (controlling cigarette consumption).

Table 1. 1 Tobacco Excise Contribution to Total Excise Revenue 2020-2023

Year	Tobacco Excise (Trillion IDR)	Total Excise (Trillion IDR)	CHT Contribution (%)
2020	170.24	176.14	96.65%
2021	188.81	195.95	96.36%
2022	218.62	226.98	96.31%
2023	213.49	217.99	97.93%

Source: Annual State Budget Realisation Reports, 2024

The Indonesian tobacco industry serves as a major employment engine, directly and indirectly supporting approximately 5.9 to 6 million workers across its value chain, including tobacco and clove farmers, factory labourers, and distribution networks (Ministry of Industry, 2019; International Labour Organisation, 2020). Table 1.2 illustrates employment distribution within Indonesia's tobacco industry, highlighting the dominance of factory labour and the continued dependence of rural communities on upstream tobacco and clove farming activities.

Table 1. 2 Data Employment Distribution

Segment	Estimated Workers
Tobacco Farmers	1.700.000
Clove Farmers	200.000
Factory Workers (SKT &SKM)	3.500.000
Distributors & Retail	700.000
Total	= 6.100.100

Source: Ministry of Industry, 2019; ILO 2020

However, this protective fiscal framework also generates policy contradictions. While the tiered structure effectively preserves employment within the hand-rolled cigarette segment, it simultaneously introduces market distortions and widens disparities between large-scale manufacturers and small producers (Adioetomo et al., 2005; Barber et al., 2008). Large producers benefit from economies of scale and greater capacity to absorb tax increases, whereas small enterprises face disproportionate compliance burdens and limited access to capital or innovation (Djuraharta et al., 2002).

A significant empirical problem confronting Indonesia's excise policy is the persistent phenomenon of downtrading: as tax rates increase, a sizeable proportion of consumers switch from higher-taxed premium products (Tier I SKM) to lower-taxed economy alternatives (Tier II SKM) or hand-rolled cigarettes (SKT), thereby undermining the fiscal effectiveness of rate increases (Chaloupka et al., 2023) (Stoklosa et al., 2019). Recent household consumption surveys found that approximately 21.2% of smokers reported actively downtrading to cheaper brands following excise-driven price hikes (PKJS-UI, 2025), a behavioral pattern corroborated by shifts in legal sales composition documented in industry reports (Badan Pusat Statistik, 2024) and confirmed empirically by econometric studies such as Prasetyo and Adrison (2020), who demonstrated that a 10% increase in Tier I prices is associated with a 5.2% increase in Tier II consumption, holding total smoking prevalence constant.

Despite extensive research on tobacco taxation and its effects on cigarette consumption and government revenue, a significant empirical and policy gap remains in Indonesia regarding the potential non-linear relationship between excise tax rates and excise revenue within its unique multi-tiered tax system. Most existing literature assumes that excise policy generates proportional or constant effects on revenue, often relying on linear specifications and constant elasticity assumptions (Chaloupka & Warner, 2000). However, in reality, the relationship between tax rates and revenue may not be linear, particularly in markets characterized by product segmentation and substitution dynamics.

Emerging studies highlight that real-world responses to excise increases include substitution across product tiers and adaptive consumer behavior (Lee, 2024; Shimul, 2024). In Indonesia's multi-tiered excise system, aggressive tariff increases have triggered a phenomenon known as downtrading, whereby consumers shift from premium cigarettes to lower-priced alternatives. This substitution mechanism suggests that revenue responses to excise increases may exhibit diminishing returns beyond certain tariff levels, potentially following a non-linear pattern consistent with Laffer-type dynamics.

1.2. Research Question

The primary objectives of this study, derived from the research question, are as follows:

1. Is the relationship between excise tax rates and excise revenue in Indonesia non-linear?
2. Does the non-linear relationship differ between SKM Tier I and Tier II?
3. How does GDP (current price) affect excise revenue dynamics?

1.3. Research Purposes

This research is designed to empirically examine the structure of the tax-revenue relationship within Indonesia's multi-tier cigarette excise system using a quadratic regression framework. The objectives are defined as follows:

1. To analyse whether the relationship between excise tax rates and excise revenue in Indonesia follows a quadratic (non-linear) pattern.

2. To compare the non-linear revenue responses between SKM Tier I and SKM Tier II in order to identify potential differences in tax effectiveness across tiers.
3. To analyse the impact of GDP at current prices on excise revenue as a macroeconomic control variable influencing revenue dynamics.

1.4. Research Scope and Novelty

The novelty of this study lies in its application of a quadratic model to examine non-linear excise revenue responses within Indonesia's multi-tiered SKM system, providing tier-specific evidence on potential revenue-maximising tax rates, which have not been empirically tested in the Indonesian context.

1.5. Writing Structure

In this thesis writing, out of the five chapters, each chapter contains:

Chapter 1 : Introduction

This chapter introduces the overall research context by explaining the fiscal and economic importance of tobacco excise policy in Indonesia. This chapter outlines the study's background, highlighting the dual role of excise taxation as both a revenue-generating instrument and a regulatory tool for controlling cigarette consumption. It identifies the phenomenon of downtrading within Indonesia's multi-tier excise system and formulates the research questions, objectives, scope, novelty, and structure of the thesis. This chapter establishes the research problem and justifies the need for examining the non-linear relationship between excise tax rates and revenue.

Chapter 2 : Literature Review

This chapter presents the theoretical and empirical foundations underpinning the study. It discusses key economic theories, including perfect competition, consumer and producer surplus, fiscal distortion, deadweight loss, excise tax theory, and the Laffer Curve framework. The chapter also reviews prior empirical studies related to tobacco taxation, revenue dynamics, and substitution behaviour. Based on theoretical synthesis and empirical gaps, this chapter develops the conceptual framework and formulates the research hypotheses that guide the econometric analysis.

Chapter 3 : Research Methodology

This chapter explains the research design and methodological approach employed to test the proposed hypotheses. It defines the research variables, data sources, population and sample, and operational measurements. The chapter describes the quadratic regression model specification and the econometric procedures used, including Ordinary Least Squares (OLS) estimation and classical assumption testing (normality, multicollinearity, heteroskedasticity, and autocorrelation). It also explains the inclusion of GDP (current price) as a macroeconomic control variable within the analytical framework.

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Chapter 4 : Result and Discussion

This chapter presents the empirical results and interprets the findings in light of the theoretical framework. It includes descriptive statistical analysis, regression estimation results, hypothesis testing, and diagnostic test outcomes. The discussion focuses on identifying whether the tax-revenue relationship follows a quadratic (non-linear) pattern and whether differences exist between SKM Tier I and Tier II. The moderating role of GDP is also examined to understand how macroeconomic conditions influence excise revenue dynamics. The chapter links empirical findings to the Laffer Curve mechanism and downtrading behaviour within Indonesia's multi-tier excise system.

Chapter 5 : Conclusion

This final chapter summarises the main findings of the study and evaluates the extent to which the research hypotheses are supported. It discusses the theoretical and policy implications of the results, particularly regarding optimal tax design and structural harmonisation within Indonesia's excise system. The chapter also outlines the limitations of the study and provides recommendations for future research to improve empirical modelling and policy evaluation in tobacco excise analysis.

CHAPTER II

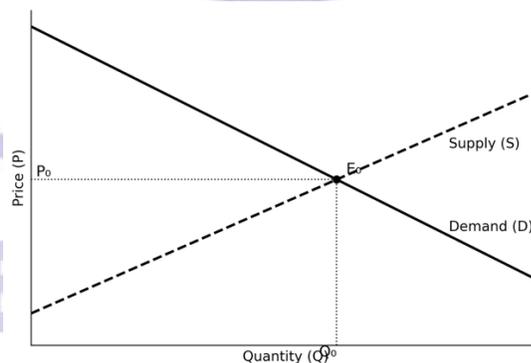
LITERATURE REVIEW

2.1. Theoretical Literature

2.1.1 Perfect Competition Market

According to O'Sullivan and Sheffrin (2007), a perfectly competitive market is characterised by numerous buyers and sellers, none of whom has the power to influence market prices. In this structure, all products are homogeneous, and both buyers and sellers act as price takers, meaning they accept the market price as given and cannot individually alter it. The determination of prices and quantities in such markets is entirely governed by the interaction between the demand and supply curves, which together set the market equilibrium. According to Pindyck & Rubinfeld (2018), a perfectly competitive market is characterised by many buyers and sellers, homogeneous products, perfect information, and free entry and exit.

Figure 2. 1 Perfect Competition Market Curve



Source: Pindyck and Rubinfeld, 2013

In such a market, neither a single firm nor a buyer can influence the price; both act as price takers. Market equilibrium occurs when aggregate demand equals aggregate supply, and the equilibrium price (P^*) and quantity (Q^*) are determined by the intersection of the demand and supply curves:

$$Q_d(P) = Q_s(P) \quad (2.1)$$

At this point:

$$P^* = \frac{a-c}{b+d}, Q^* = a - bP^* \quad (2.2)$$

This equilibrium ensures that resources are allocated efficiently, with marginal benefit (MB) = marginal cost (MC).

Demand reflects the willingness and ability of consumers to purchase goods at various prices. At the same time, supply indicates the decisions of producers about how much to offer for sale at those prices. The intersection of the demand and supply curves establishes the equilibrium price and quantity. At this equilibrium, the market achieves both allocative and productive efficiency, as no participant has an incentive to change their behaviour or influence the outcome (Mankiw, 2021; Varian, 2014).

However, when the government imposes interventions such as excise taxes, the equilibrium is distorted. Excise taxation effectively increases producers' marginal costs, shifting the supply curve leftward and raising equilibrium prices while reducing the equilibrium quantity traded (Chaloupka et al., 2012).

In the context of tobacco markets, such price increases discourage consumption but also lead to cross-tier substitution behaviour, where consumers shift demand from higher-taxed products (Tier I) to lower-taxed alternatives (Tier II).

This substitution effect, known as downtrading (Stoklosa et al., 2019; Kostova et al., 2017), changes both market composition and fiscal outcomes. Under the multi-tier excise system, the Tier I segment operates closer to the conditions of perfect competition due to higher production capacity and price transparency. Meanwhile, Tier producers, facing lower excise rates, may attract price-sensitive consumers.

According to this dual mechanism, there may not always be a linear link between excise tax rates and revenue. Because there is little quantity loss at relatively low tax rates, increases in excise typically result in higher overall income. However, beyond a specific threshold, additional tax rate increases may result in significant decreases in consumption, which would decrease overall revenue. This theoretical mechanism aligns with the Laffer Curve hypothesis, which posits a concave (inverted-U) relationship between tax rates and tax revenue.

In Indonesia's multi-tier excise system, this non-linear revenue response may vary between SKM Tier I and Tier II segments. However, the underlying mechanism is still the same: in a skewed competitive market, the interplay between tax rates and quantity responses drives revenue dynamics. This study used a quadratic specification to empirically examine whether excise revenue demonstrates a non-linear reaction to variations in tax rates.

2.1.2 Consumer & Producer Surplus

Under competitive equilibrium, consumer surplus and producer surplus are common metrics of welfare that show how a market divides advantages between consumers and producers (Varian, 2010; Pindyck & Rubinfeld, 2018). In a perfectly competitive market, equilibrium is established at the intersection of the demand and supply curves at (P^*, Q^*) . At this equilibrium, the total welfare produced by market exchange is the aggregate of consumer surplus (CS) and producer surplus (PS). These metrics are especially significant in excise-tax research because taxation affects equilibrium prices and quantities, redistributing excess and potentially lowering total welfare through deadweight loss.

The additional benefit that consumers receive when the market price is less than their maximal willingness to pay is measured monetarily as consumer surplus (Mankiw, 2021; Varian, 2010). The area under the demand curve and above the market price P^* up to the equilibrium quantity Q^* is represented graphically as consumer surplus. It can be formally expressed as:

$$CS = \int_0^{Q^*} (P(Q) - P^*) dQ \quad (2.3)$$

Where:

P^* : actual market price

Q^* : equilibrium quantity

Where the inverse demand function is represented by $P(Q)$, the equilibrium price by P^* , and the equilibrium quantity by Q^* . When policies like excise taxes raise

consumer prices, the area reflecting consumer surplus shrinks because customers pay a higher price and buy fewer items. This process explains why raising excise taxes often lowers consumer welfare, particularly for groups that are price-sensitive.

Producer surplus, which is closely tied to marginal cost, represents the additional financial gain that producers earn when they are paid more than the lowest price they are willing to accept (Mankiw, 2021; Varian, 2010). Since the supply curve and the marginal cost (MC) curve under perfect competition are equal, producer surplus is the region above the supply curve and below the market price P^* up to Q^* . Pindyck and Rubinfeld (2018) define producer surplus as follows:

$$PS = \int_0^{Q^*} [P^* - MC(Q)] dQ \quad (2.4)$$

Explanation:

- P^* : Market equilibrium price
- $MC(Q)$: Marginal cost function (which is also the firm's supply curve under perfect competition)
- Q^* : Equilibrium quantity

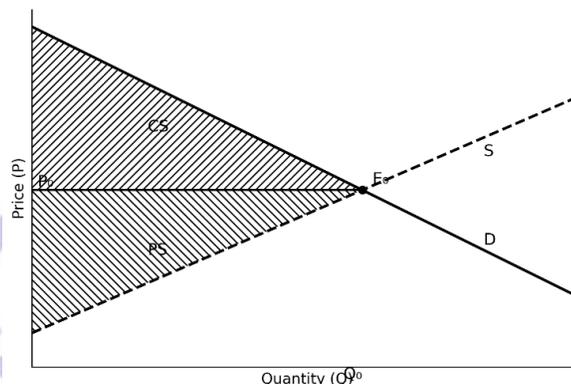
Where P is the equilibrium market price, Q is the equilibrium quantity, and $MC(Q)$ is the marginal cost function (and the firm's supply curve under perfect competition). The effective net price that producers receive tends to decrease when excise taxes are implemented; in other words, the tax creates a wedge between the producer and consumer prices. Because producers either sell less or obtain a lower net price, producer surplus consequently decreases. Based on empirical evidence, excise

policies in Indonesia have the potential to decrease producer welfare, particularly for market groups that are subject to significant tax hikes (Suprianti et al., 2019).

The welfare framework of CS and PS offers a direct connection to market distortion in the context of excise taxation. In addition to providing a portion of surplus to the government as tax revenue, excise taxes also result in an efficiency loss (deadweight loss) from missed transactions by increasing consumer prices and decreasing equilibrium quantities (Varian, 2010). Crucially, welfare changes in cigarette markets with a multi-tier excise structure can also happen through replacement between tiers rather than just through decreases in overall consumption. According to the downtrading phenomenon, customers may choose lower-tier alternatives when higher-tier tax rates raise retail costs for premium goods (Stoklosa et al., 2019; Kostova et al., 2017). This tier substitution suggests that consumer surplus may diminish more significantly for premium customers, whereas producers in the higher-tax tier may face a more pronounced decrease in producer surplus.

On the other hand, demand moving toward more reasonably priced goods may assist producers in lower tax tiers to some extent, while the overall welfare impact still depends on the size of the quantity contraction and the tax wedge.

Figure 2. 2 Consumer & Producer Surplus



Source: Pindyck and Rubinfeld, 2013

The competitive equilibrium is skewed when excise taxes are applied. The tax increases producers' marginal costs, resulting in an upward shift of the supply curve and establishing a disparity between the price consumers pay and the price producers receive. As a result, producer surplus falls as a result of lower net prices and fewer sales, consumer surplus shrinks as a result of higher prices, and equilibrium quantity falls. Excise taxes produce deadweight loss, which is the efficiency loss from transactions that are not completed, in addition to redistributing a portion of the surplus to the government as tax revenue.

Crucially, the trade-off between higher tax rates and lower quantities required determines revenue dynamics since excise revenue is calculated as the product of the tax rate and the amount sold. Even if consumer and producer surplus declines, increases in excise taxes may improve overall revenue at relatively low tax levels. But after a while, additional tax hikes might cause a significant drop in quantity, which would lower overall excise revenue. According to the Laffer Curve hypothesis, this

mechanism suggests that there is a theoretically non-linear relationship between excise tax rates and excise revenue.

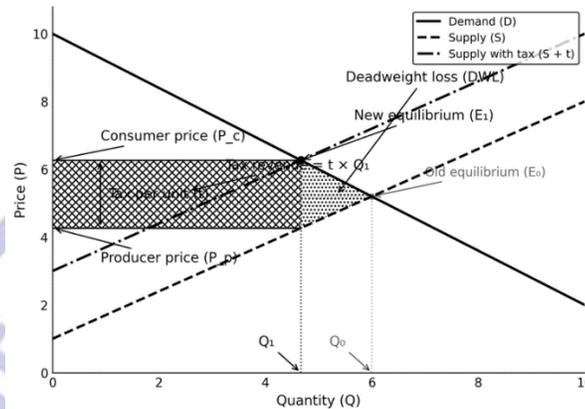
Both SKM Tier I and Tier II sectors are subject to this non-linear revenue method under Indonesia's multi-tier excise system. Although reductions in consumer and producer surplus in each tier lead to welfare reductions, the empirical focus of this study is on whether revenue responds to tax adjustments in a quadratic (concave) pattern rather than on surplus redistribution per se. Consequently, the quadratic specification is used to account for the potential that revenue may rise with tax rates at first before falling once it reaches an ideal threshold.

2.1.3 Fiscal Policy, Market Distortion, and Deadweight Loss

Fiscal instruments, such as taxes and excise duties, are key tools in government policy aimed at generating revenue and influencing market behaviour. However, when applied to specific goods such as cigarettes. Taxes also create market distortions because they drive a wedge between the price consumers pay and the price producers receive relative to the market equilibrium. According to Varian (2010), when the government levies a tax (including excise), the supply curve shifts to the left (or upward), causing consumers to pay a higher price and producers to receive a lower net price. This finding results in a decrease in the total quantity traded compared to the efficient equilibrium without tax, leading to market inefficiency.

The core welfare impact of such distortions is known as deadweight loss: the loss of total surplus (the combined surplus of consumers and producers) that is not offset by government revenue.

Figure 2. 3 Deadweight Loss Curve



Source: Pindyck & Rubinfeld (2013)

Excise taxation serves as both a significant source of fiscal revenue and a tool to deter cigarette consumption in the context of the Indonesian cigarette industry, specifically the Machine-made Cigarette (Sigaret Kretek Mesin) Tier I and Tier II segments. In a competitive market, increases in excise taxes elevate the supply curve, leading to higher retail prices and reduced equilibrium quantities.

Different segments may be impacted differently by tax modifications in a multi-tier excise structure. Premium (Tier I) products typically see more drastic retail price increases due to higher tax rates, which may lower quantity requested and change the makeup of the market as a whole. The relationship between tax rates and quantity responses continues to be the primary mechanism influencing fiscal outcomes, despite the possibility of tier substitution (also known as downtrading). Revenue dynamics show a trade-off because excise revenue is calculated as the product of the tax rate and

the amount sold. Higher tax rates result in higher revenue per unit, but they also lower the quantity requested.

Because of this trade-off, excise revenue might not react to changes in tax rates in a linear fashion. Excise hikes may improve overall revenue even when quantity is decreased at relatively low tax levels. However, after a certain point, additional tax rate hikes could cause a significant decline in demand, which would lower overall excise revenue. A concave (inverted-U) relationship between excise tax rates and excise revenue is suggested by this theoretical process, which is in line with the Laffer Curve hypothesis. This study employs a quadratic specification to account for potential non-linearity, allowing revenue to increase at lower tax rates and decline after exceeding an optimal threshold.

Macroeconomic conditions, represented by GDP at current prices (PDBHB), are included as a control variable reflecting aggregate demand and overall economic performance. Higher aggregate income may maintain consumption levels in the face of price increases during economic expansions, which would affect the total amount of excise tax collected. On the other hand, a weaker economy could make quantity contraction more pronounced in reaction to higher taxes. Although GDP includes more general economic characteristics that impact revenue performance, it does not change the fundamental relationship between tax rates and revenue.

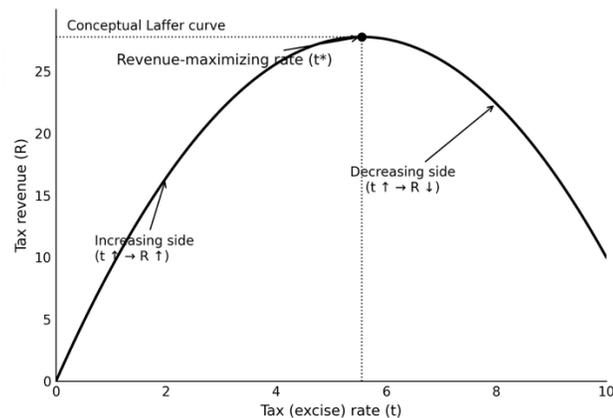
2.1.4 Excise Tax Theory

Excise tax is a selective levy imposed on specific goods with negative externalities, such as tobacco and alcohol. As noted by Cnossen (2015), excise is characterised by its selective object, discriminatory purpose, and reliance on quantitative measures to set rates. Excise aims to generate government revenue efficiently, internalise externalities, and control the consumption of harmful goods. (Hines, 2007). In Indonesia's legal system, excise regulation is established under Law Number 39 of 2007 on Excise. Article 1 defines excise as a levy imposed by the state on specific goods with certain special characteristics. Article 2 further explains that qualifying goods are those whose use could harm society or the environment, making them appropriate targets for specific levies to promote social justice alongside economic welfare. Article 4 of Law Number 39 of 2007 details the types of goods subject to excise, including ethyl alcohol, beverages containing any level of ethyl alcohol, concentrates containing ethyl alcohol, and tobacco products. Tobacco products comprise items such as cigarettes, sliced tobacco, and other processed tobacco goods. Hence, excise policy serves to regulate the consumption of products that pose health and social risks. Within the Indonesian context, the multi-tiered tobacco excise structure creates the potential for market distortions and consumption shifting toward lower tax segments, thereby challenging the effectiveness of fiscal policy in controlling consumption and optimising government revenue (Prasetyo & Adrison, 2020; JIPAK, 2022).

2.1.5 Laffer Curve

The Laffer Curve shows how tax rates and total government revenue are theoretically related. Laffer (2004) and Varian (2010) argue that an optimal tax rate exists for maximising revenue. Since each unit is taxed very little when tax rates are set very low, government revenue is still constrained. However, revenue may decrease when tax rates rise too high since this discourages consumption and production, shrinks the tax base, and changes economic behavior.

Figure 2. 4 Laffer Curve



Source: Laffer, 2004

The Laffer Curve illustrates the theoretical relationship between tax rates and government revenue. Conceptually, the curve suggests that revenue is zero at a tax rate of 0 percent, since no tax is collected, and also zero at a tax rate of 100 per cent, because economic agents have no incentive to produce, transact, or participate in the formal market. Between these two extremes, there exists an optimal tax rate at which

government revenue is maximised. This relationship implies a non-linear and concave (inverted-U) curve.

The theoretical foundation of the Laffer Curve is based on two central mechanisms: the arithmetic effect and the economic effect. The arithmetic effect assumes that, holding the tax base constant, an increase in the tax rate mechanically raises government revenue. In contrast, the economic effect recognises behavioural responses to taxation. Higher tax rates may discourage production, reduce consumption, incentivise substitution toward lower-taxed goods, or even encourage tax avoidance and informal market activity. As a result, the taxable base may contract when tax rates rise beyond a certain threshold (Mankiw, 2021; Ebrill, 1987).

When tax rates are relatively low, the arithmetic effect dominates, and revenue increases as tax rates rise. However, once tax rates exceed the revenue-maximising point, the economic effect becomes stronger than the arithmetic effect. In this region, further increases in tax rates reduce the tax base more than proportionally, causing total revenue to decline. This trade-off between rate increases and quantity contraction forms the theoretical basis of the inverted-U shape.

Empirically, the inverted-U condition consistent with the Laffer hypothesis requires two econometric conditions in a quadratic specification:

1. The coefficient of the linear tax term must be positive ($\beta_1 > 0$).
2. The coefficient of the squared tax term must be negative ($\beta_2 < 0$).

When these conditions are satisfied and statistically significant, the model indicates that revenue first increases and then decreases as tax rates rise, implying the existence of a revenue-maximising turning point.

Within Indonesia's multi-tier tobacco excise framework, characterised by distinct tax rates for Tier I and Tier II producers (TAX1 and TAX2), the Laffer mechanism suggests that revenue responses may differ across segments. Moderate increases in excise rates may enhance revenue through the arithmetic effect. However, excessive increases may lead to substantial reductions in sales volume or induce downtrading behaviour from higher-taxed to lower-taxed tiers, reflecting the economic effect. Although the multi-tier structure allows substitution across segments, the fundamental mechanism remains the trade-off between higher rates and lower quantity demanded.

2.2 Empirical Evidence

Research on how cigarette taxes, prices, and income levels affect smoking behaviours and government revenue has been conducted by many researchers, and these studies serve as references for this study.

Table 2. 1 Summary of Past Studies

No.	Author(s), Year, and Title	Research Methods and Variables	Research Findings
1.	Author: Fullerton, D. Year: 1982 Title: On the possibility of an inverse relationship between tax rates and government revenues	Method: Quadratic OLS Dependent Variable: Government Revenue Independent Variable: Tax Rate, Tax ²	The quadratic model shows positive linear tax coefficient ($\beta_1 > 0$) and negative squared term ($\beta_2 < 0$), confirming inverted-U relationship where revenue increases at low tax rates but declines beyond optimal threshold.
2.	Author: Trabandt & Uhlig Year: 2011 Title: The Laffer curve revisited	Method: DSGE + Quadratic Dependent Variable: Tax Revenue Independent Variable: Tax Rate, Tax ² , Elasticity	Empirical analysis across EU countries reveals most tax rates lie left of Laffer peak, with revenue-maximizing rate around 60% depending on labor supply elasticity.
3.	Author: Chaloupka & Warner Year: 2000 Title: The economics of smoking	Method: Meta-analysis Dependent Variable: Cigarette Demand Independent Variable: Price, Income, Tax	Cigarette price elasticity averages -0.4, with significant downtrading observed in tiered tax markets where consumers substitute higher-priced premium brands for cheaper alternatives
4.	Author: Gallet & List Year: 2003	Method: Meta-regression	Meta-analysis of 360+ estimates shows price elasticity ranges

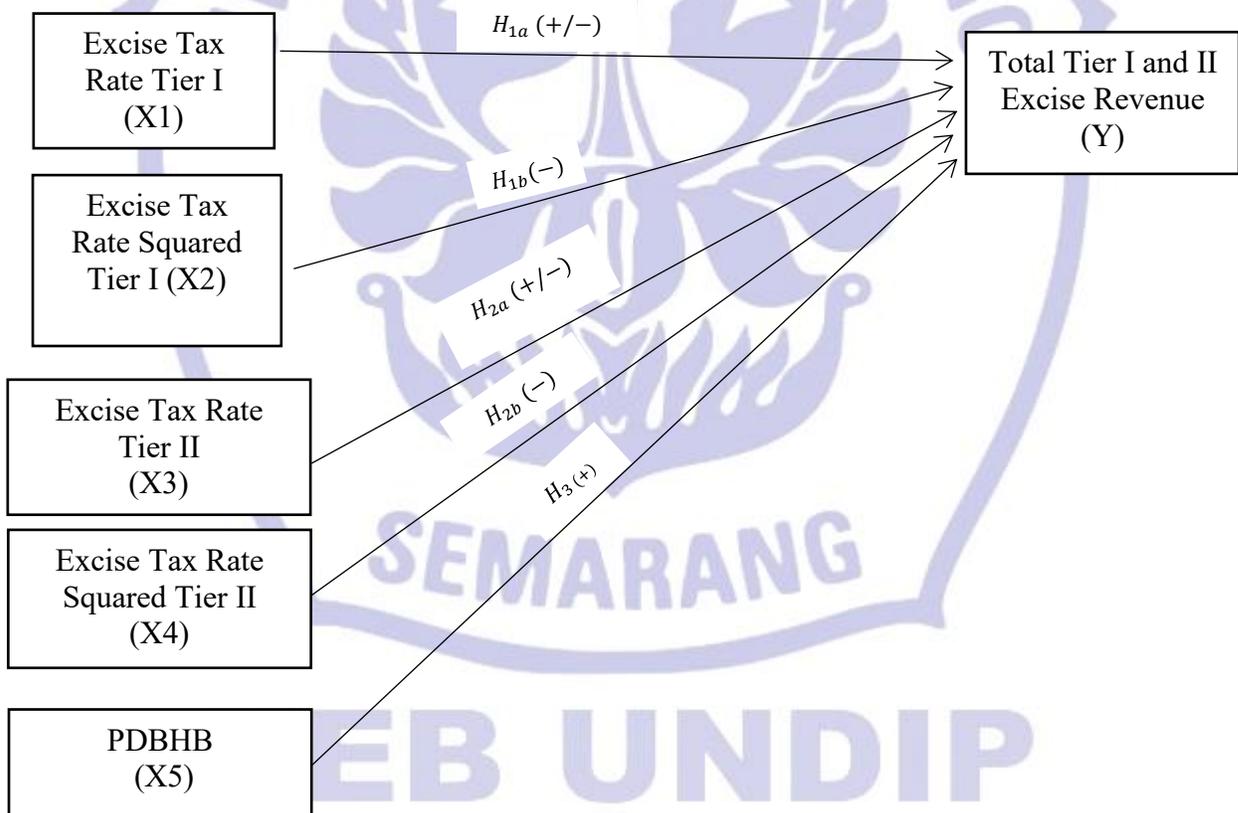
No.	Author(s), Year, and Title	Research Methods and Variables	Research Findings
	Title: Cigarette demand: A meta-analysis	Dependent Variable: Price Elasticity Independent Variable: Tax Rate, Income	from -0.2 to -0.8, becoming more elastic at higher tax levels, indicating non-linear demand response.
5.	Author: Laffer, A.B. Year: 2004 Title: The Laffer Curve: Past, Present, and Future	Method: Theoretical + Simulation Dependent Variable: Revenue Independent Variable: Tax Rate, Tax ²	Revenue equals zero at both 0% and 100% tax rates, reaching maximum at optimal rate of 20-30% for excise taxes due to behavioral substitution effects.
6.	Author: Chaloupka et al. Year: 2019 Title: Tobacco taxes as a tobacco control strategy	Method: Panel Regression Dependent Variable: Consumption Independent Variable: Excise Tax, Price	A 10% excise tax increase reduces consumption by 4% on average, but Tier 2 substitution significantly weakens revenue gains in multi-tiered systems.
7.	Author: Ross & Chaloupka Year: 2006 Title: Economic policies for tobacco control	Method: Cross-country Panel Dependent Variable: Smoking Prevalence Independent Variable: Tax Rate, Policy Mix	Excise taxes prove most effective in low/middle-income countries, though tiered structures reduce impact through cross-brand substitution behavior.
8.	Author: World Bank Year: 2017	Method: Simulation Model	Uniform tax rates increase revenue 15% compared to multi-tier systems, while downtrading

No.	Author(s), Year, and Title	Research Methods and Variables	Research Findings
	Title: Tobacco Tax Reform at the Crossroads	Dependent Variable: Revenue & Health Independent Variable: Tiered Tax Rates	reduces projected fiscal gains by approximately 10%.
9.	Author: Slemrod, J. Year: 1998 Title: Optimal taxation and optimal tax systems	Method: Theoretical Model Dependent Variable: Revenue Maximization Independent Variable: Tax Rate, Compliance	Optimal tax rate balances arithmetic revenue effect against economic behavioral responses including substitution, evasion, and reduced compliance.
10.	Author: Cremer & Gahvari Year: 1993 Title: Tax evasion and optimal commodity taxation	Method: Theoretical + Simulation Dependent Variable: Tax Revenue Independent Variable: Tax Rate, Evasion	Higher tax evasion shifts quadratic revenue peak leftward, requiring lower optimal rates to maximize net collections after accounting for noncompliance.
11.	Author: Ebrill et al. Year: 2001 Title: The Modern VAT	Method: Cross-country Analysis Dependent Variable: VAT Revenue Independent Variable: VAT Rate, Rate ²	Quadratic specification confirms negative squared VAT coefficient significant in 80% of countries, validating Laffer curve dynamics for indirect taxes.
12.	Author: Keen, M. Year: 2012	Method: Panel Data	Developing countries achieve optimal excise rates of 15-25%

No.	Author(s), Year, and Title	Research Methods and Variables	Research Findings
	Title: Taxation and development— Again	Dependent Variable: Tax-GDP Ratio Independent Variable: Tax Rate, Structure	of retail price, balancing revenue maximization with consumption substitution effects.

Source: Collected from Several Articles, 2025

2.2. Theoretical Framework

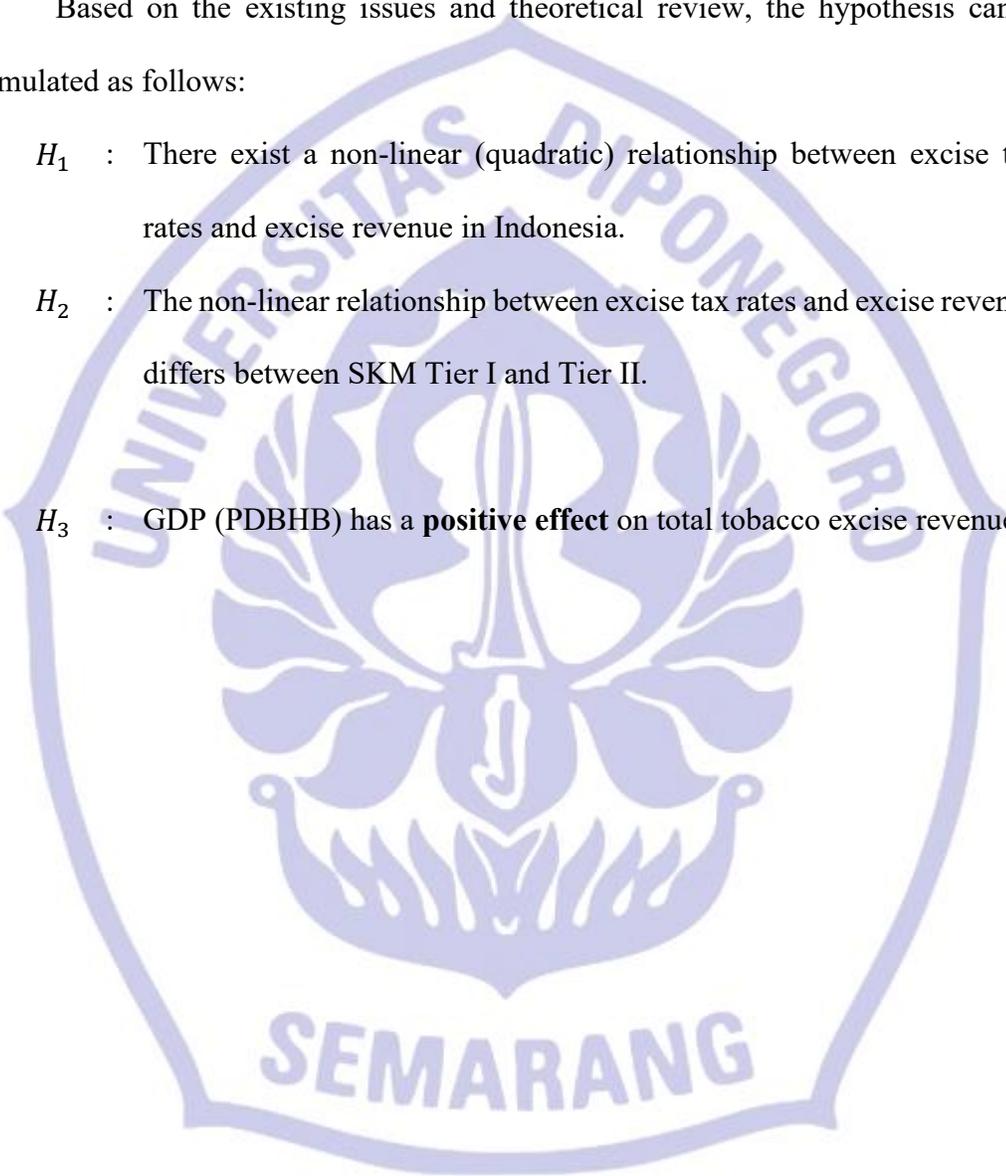


Source: Author, 2026

2.3. Research Hypothesis

Based on the existing issues and theoretical review, the hypothesis can be formulated as follows:

1. H_1 : There exist a non-linear (quadratic) relationship between excise tax rates and excise revenue in Indonesia.
2. H_2 : The non-linear relationship between excise tax rates and excise revenue differs between SKM Tier I and Tier II.
3. H_3 : GDP (PDBHB) has a **positive effect** on total tobacco excise revenue.



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CHAPTER III

RESEARCH METHOD

3.1 Research Variables and Operational Definitions

3.1.1. Dependent Variable

The dependent variable in this study is tobacco excise income at the tier level, namely excise revenue from SKM Tier I (REV1) and SKM Tier II (REV2). These variables indicate government revenue derived from excise taxes on machine-manufactured cigarettes within each level of Indonesia's multi-tier excise framework. This study utilizes tier-specific revenue as the dependent variable to investigate whether the connection between excise tax rates and revenue demonstrates a non-linear (quadratic) pattern within each segment. Instead of depending on total income, the study accounts for possible variations in revenue responses across tax categories by dividing the models for Tier I and Tier II. The quarterly excise income obtained from Tier I and Tier II cigarette manufacturers is used as the operational metric for REV1 and REV2, respectively. The data is sourced from official publications of the Directorate General of Customs and Excise (DJBC), Ministry of Finance of the Republic of Indonesia, and is presented in Indonesian Rupiah (IDR).

3.1.2. Independent Variable

The study's variables include GDP at current prices (PDBHB), the excise tax rates for Tier I (TAX1) and Tier II (TAX2), and their squared terms (TAX1² and

TAX2²). The applicable excise rates for machine-made cigarettes in each tier are denoted by TAX1 and TAX2. According to the Laffer Curve theory, the model may account for possible non-linear (quadratic) impacts of excise taxes on revenue by using squared tax terms. This study investigates whether excise revenue responds to increases in tax rates in a concave (inverted-U) pattern, where revenue may initially rise with higher tax rates but then fall after crossing a specific threshold, rather than assuming a purely positive relationship. Theoretically, higher tax rates and smaller taxable bases as a result of falling quantity demanded are traded off in this specification.

Gross Domestic Product at current prices (PDBHB) serves as a macroeconomic control measure indicative of overall economic activity and purchasing power. Increased GDP levels are expected to affect the total volume of excise revenue by increasing economic transactions and consumption, however GDP does not modify the fundamental form of the tax-revenue relationship.

This study assesses whether the non-linear revenue response varies across sectors within Indonesia's multi-tier excise system by dividing the estimation for Tier I and Tier II revenue (REV1 and REV2).

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3.1.3. Data Types and Source

Table 3. 1 Operational and Data Sources

Variable	Definition	Unit	Data Source
REV1 & REV2	Government revenue from cigarette excise taxes for machine-made kretek (<i>Sigaret Kretek Mesin</i>) Tier I and II, measured quarterly	Trillion Rupiah	Directorate General of Customs and Excise (DJBC), Ministry of Finance
TAX1 & TAX2	The excise tax rate per cigarette stick, as determined by the government for each tier	Rupiah per stick	Minister of Finance Regulation (PMK), annual excise tax policy documents
TAX1² & TAX2²	The squared value of the Tier I & Tier II excise tax rate, included to capture the potential quadratic relationship between tax rates and excise revenue	Rupiah per stick	Minister of Finance Regulation (PMK), annual excise tax policy documents
PDBHB	The total value of goods and services produced in the Indonesian economy at current prices per period, reflecting macroeconomic conditions.	Million	Badan Pusat Statistik

Source: Author's Compilation, 2026

3.2. Population and Research Sample

The population of this study comprises all historical data related to cigarette excise tax policy, excise revenue from Machine-Made Kretek Cigarettes (*Sigaret*

Kretek Mesin/ SKM) Tier I and Tier II, and macroeconomic indicators in Indonesia during the period 2017–2024. This includes all recorded excise tax rates for Tier I (TAX1) and Tier II (TAX2), excise revenue from each tier, as well as GDP at current prices (PDBHB) as a proxy for overall economic activity. Conceptually, the population represents the entire set of relevant time-series observations reflecting the dynamics of excise policy and revenue performance in Indonesia within the specified period.

The sample of this study consists of quarterly time-series data from the first quarter of 2017 (2017Q1) to the fourth quarter of 2024 (2024Q4), resulting in 32 observations. The sampling technique employed is purposive sampling, based on specific criteria aligned with the research objectives, namely: (1) availability of quarterly data, (2) completeness of variables required for the quadratic regression model, including excise tax rates, squared tax terms, excise revenue, and GDP at current prices, and (3) consistency of data sources from the Directorate General of Customs and Excise (DJBC) and Statistics Indonesia (BPS).

Due to data adjustment during the estimation process in the econometric software, the effective number of observations used in the regression analysis is 31. This adjustment occurs as a result of data transformation and estimation procedures. Nonetheless, the quarterly sample adequately captures the evolution of excise tax policy and macroeconomic conditions in Indonesia over the study period.

3.3. Types and Source of Data

This study utilizes secondary data sourced from official government agencies, as all variables involve macroeconomic and fiscal indicators that have undergone validation and quality assurance processes. The adoption of secondary data ensures a high level of reliability and suitability for rigorous time series analysis. The research employs quarterly time series data spanning from the first quarter of 2017 (2017Q1) to the fourth quarter of 2024 (2024Q4), a period selected to capture significant changes in Indonesia's cigarette excise tax structure and to encompass both pre- and post-policy reform phases. This approach enables a comprehensive analysis of the evolution and impact of excise tax policy, drawing on credible datasets from the Directorate General of Customs and Excise (DJBC) for fiscal variables and Statistics Indonesia (BPS) for macroeconomic indicators.

3.4. Data Analysis Method

This research utilizes time series regression analysis using the Ordinary Least Squares (OLS) method to investigate the determinants of downtrading in SKM cigarettes and its fiscal effects on excise revenue. The OLS methodology is adopted because, under the Gauss-Markov conditions, it yields the BLUE, assuming linearity, absence of perfect multicollinearity, zero mean of errors, homoskedasticity, and no autocorrelation among errors (Gujarati & Porter, 2009; Wooldridge, 2016). To prevent spurious regression, a common issue in time series analysis, stationarity of each

variable was rigorously evaluated using the Augmented Dickey-Fuller (ADF) test, following established best practices (Enders, 2015).

The classical assumptions underlying OLS estimation were systematically tested: normality was assessed using the Jarque-Bera test; multicollinearity was examined via the Variance Inflation Factor (VIF); autocorrelation was assessed using the Breusch-Godfrey LM test; and heteroskedasticity was assessed through the Breusch-Pagan-Godfrey test. In instances where diagnostic tests revealed violations of homoskedasticity or autocorrelation, heteroskedasticity- and autocorrelation-consistent (HAC/Newey-West) robust standard errors were utilised to ensure valid and consistent inference (Newey & West, 1987).



3.4.1. Regression Equation Model 1

$$REV1_t = \beta_0 + \beta_1 TAX1_t + \beta_2 TAX1_t^2 + \beta_3 PDBHB_t + \varepsilon_t \quad (3.1)$$

Explanation:

$REV1_t$: Total tobacco excise revenue in period t

β_0 : Constant

$TAX1_t$: Tier I cigarette excise rate in period t

$TAX1_t^2$: The square of the SKM Tier I excise rate in period t

$PDBHB_t$: Gross Domestic Product at current prices in period t

ε_t : Error Term

3.4.2. Regression Equation Model 2

$$REV2_t = \beta_0 + \beta_1 TAX2_t + \beta_2 TAX2_t^2 + \beta_3 PDBHB_t + \varepsilon_t \quad (3.2)$$

Explanation:

$REV2_t$: Tobacco excise revenue Tier II in period t

β_0 : Constant

$TAX2_t$: Tier II cigarette excise rate in period t

$TAX2_t^2$: The square of the SKM Tier II excise rate in period t

$PDBHB_t$: Gross Domestic Product at current prices in period t

ε_t : Error Term

3.5. Method of Analysis

There are several widely accepted approaches for estimating time series regression models, and their selection depends on the underlying characteristics of the data. In this method, five approaches can be employed:

a. *Ordinary Least Squares* (OLS)

OLS is the primary approach for estimating linear time series regressions where the assumptions of classical linear regression (stationarity, homoskedasticity, and no autocorrelation) are not violated. OLS estimation is widely accepted due to its simplicity and interpretability, as supported by Enders (2015) and Wooldridge (2016).

b. *Generalized Least Squares* (GLS) and *Weighted Least Squares* (WLS):

These methods are used when error terms exhibit heteroskedasticity or autocorrelation, as GLS provides efficient parameter estimates in the presence of such violations. The use of robust estimators has been rigorously discussed in econometric literature and applied to time series research.

c. *Maximum Likelihood Estimation* (MLE):

MLE is commonly employed in more complex time series such as ARIMA, GARCH, or nonlinear models, and has been shown to provide consistent and asymptotically efficient parameter estimates (Box & Jenkins, 1976).

d. *Autoregressive Distributed Lag* (ADRL) and *Error Correction Model* (ECM):

ADRL models allow for flexible lag structures and are beneficial for modeling both short-term dynamics and long-run equilibria; ECM is employed when

cointegration between variables is found, providing both long and short-run insights (Wooldridge, 2016; Enders, 2015).

e. *Robust Regression* and HAC (Newey-West) Standard Errors:

When classical assumptions are violated, robust regression techniques or heteroskedasticity and autocorrelation-consistent (HAC) standard errors are applied to achieve valid statistical inference.

3.5.1. Classical Assumption Test

In regression analysis, it is essential to conduct classical assumption tests to determine whether the parameter estimates are unbiased and to evaluate the suitability of the model used (Sugiyono, 2017). In this study, the following classical assumption tests are applied:

a. Normality Test

The normality test is used to assess whether the distribution of residual values is normal. A normal distribution of residuals suggests minimal bias in the model estimates. The test is conducted using the Jarque-Bera statistical method, which can also be visualised with a residual histogram. According to Jarque and Bera (1987), the Jarque-Bera statistic is defined as:

$$JB = \frac{n}{6} \left(S^2 + \frac{(K - 3^2)}{4} \right) \quad (3.3)$$

Where:

n = the number of observations

S = the skewness of the residuals

K = the kurtosis of the residuals

Under the null hypothesis of normality, the Jarque-Bera statistic asymptotically follows a chi-square distribution with two degrees of freedom ($\chi^2(2)$). The decision rule for the Jarque-Bera test is as follows:

- If the Prob. Value of the Jarque-Bera > 0.05 , the data are considered to be normally distributed.
- If the Prob. Value of the Jarque-Bera < 0.05 , the data are considered not to be normally distributed.

b. Multicollinearity Test

The multicollinearity test is conducted to ensure that there is no significant intercorrelation or collinearity among the independent variables within a regression model. One standard method for detecting multicollinearity is by examining the correlation values. If the correlation values are less than 0.8, it can be inferred that the independent variables are free from serious multicollinearity issues. One commonly used preliminary approach to detect multicollinearity is the pairwise correlation analysis among independent variables. According to Karl Pearson (1895), the correlation coefficient between two independent variables x_i and x_j is defined as:

$$P_{ij} = \frac{\sum_{t=1}^n (X_{it} - \bar{X}_i)(X_{jt} - \bar{X}_j)}{\sqrt{\sum_{t=1}^n (X_{it} - \bar{X}_i)^2} \sqrt{\sum_{t=1}^n (X_{jt} - \bar{X}_j)^2}} \quad (3.4)$$

Where:

X_{it} and X_{jt} : observations of variables i and j at time t

\bar{X}_i and \bar{X}_j : their respective means

n: the number of observations

Following common econometric practice, if the absolute value of the correlation coefficient between independent variables is less than 0.80, the model is considered free from serious multicollinearity problems. Conversely, a correlation coefficient exceeding this threshold may indicate potential multicollinearity concerns.

c. Heteroskedasticity Test

Heteroskedasticity testing aims to determine if the variance of the residuals differs across observations in a linear regression model. This study applies the Breusch-Pagan-Godfrey (BPG) test using E-Views to evaluate this assumption. The null hypothesis (H_0) assumes constant variance of error terms (homoskedasticity), whereas the alternative hypothesis (H_1) indicates heteroskedasticity, meaning residual variances vary across observations. According to Breusch, T.S., & Pagan, A.R. (1979), the BPG test is based on the auxiliary regression:

$$\hat{u}_t^2 = \alpha_0 + \alpha_1 Z_{1t} + \alpha_2 Z_{2t} + \dots + \alpha_k Z_{kt} + v_t \quad (3.5)$$

Where:

\hat{u}_t^2 = the squared residuals obtained from the original regression model

Z_{kt} = the explanatory variables (or a subset thereof) suspected of influencing the error variance

v_t = the disturbance term of the auxiliary regression

The Breusch-Pagan-Godfrey test statistic is defined as:

$$LM = n \cdot R^2 \quad (3.6)$$

Where:

n = the number of observations

R^2 = the coefficient of determination obtained from the auxiliary regression

Under the null hypothesis of homoskedasticity, the LM statistic asymptotically follows a chi-square distribution with k degrees of freedom ($\chi^2(k)$), where k is the number of explanatory variables in the auxiliary regression. The decision rule is as follows:

- If the probability exceeds 0.05, H_0 it cannot be rejected, confirming homoskedasticity and satisfying a key classical regression assumption.
- If the probability is below 0.05, heteroskedasticity exists, indicating residual variance inequality, which may lead to inefficient parameter estimates.

d. Autocorrelation Test

The autocorrelation test is used to identify whether there is a correlation between the residuals of one observation and those of other observations within a study. Autocorrelation is particularly common in time series data, as previous values often influence current values. One standard method for detecting the presence of autocorrelation in regression residuals is the Durbin-Watson statistic. The Durbin-Watson statistic is defined as:

$$DW = \frac{\sum_{t=2}^n (e_t - e_{t-1})^2}{\sum_{t=1}^n e_t^2} \quad (3.7)$$

Where:

e_t : the residual at time t

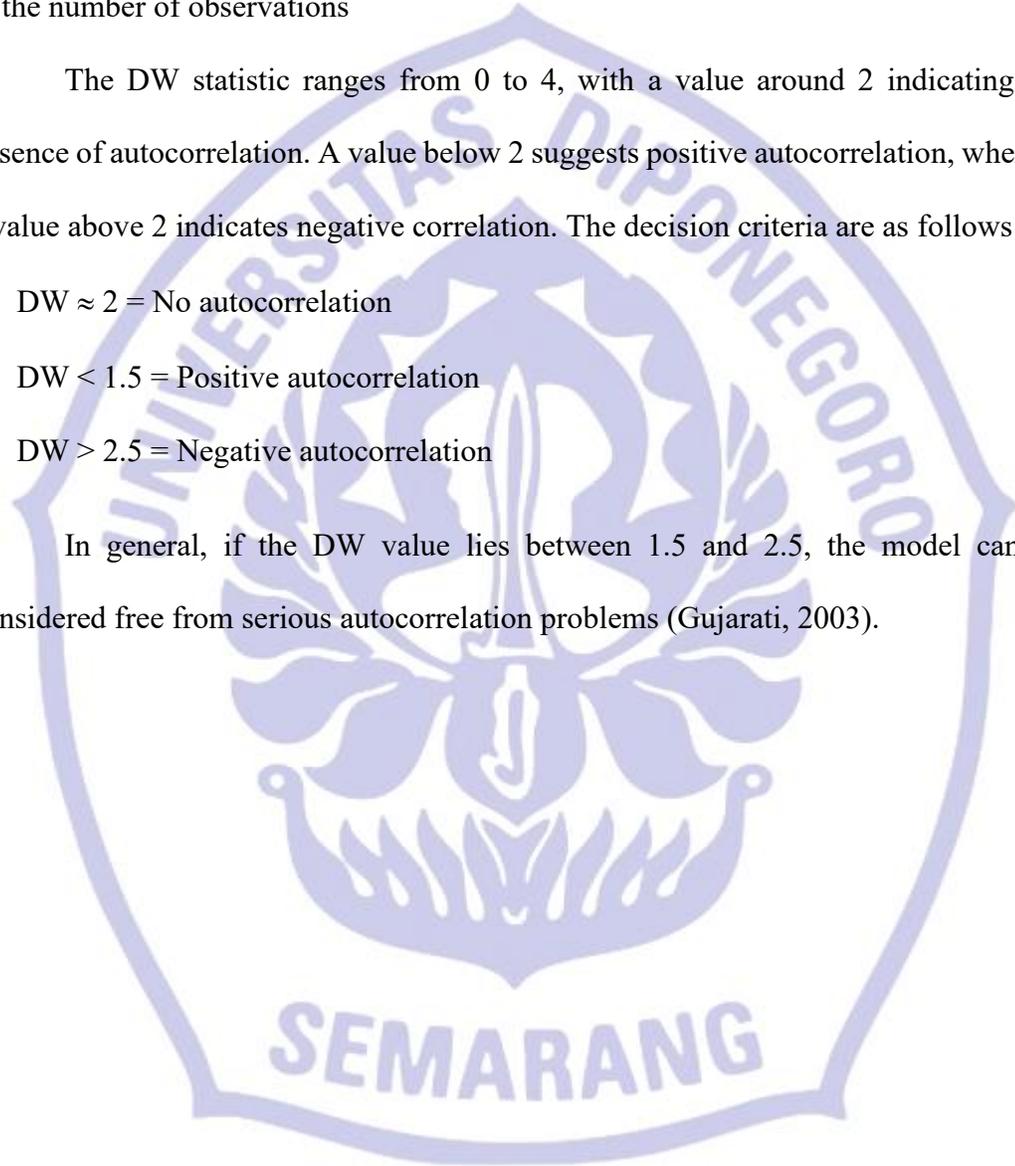
e_{t-1} : the residual at time $t - 1$

n : the number of observations

The DW statistic ranges from 0 to 4, with a value around 2 indicating the absence of autocorrelation. A value below 2 suggests positive autocorrelation, whereas a value above 2 indicates negative correlation. The decision criteria are as follows:

- $DW \approx 2$ = No autocorrelation
- $DW < 1.5$ = Positive autocorrelation
- $DW > 2.5$ = Negative autocorrelation

In general, if the DW value lies between 1.5 and 2.5, the model can be considered free from serious autocorrelation problems (Gujarati, 2003).



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CHAPTER IV

ANALYSIS AND DISCUSSION

4.1. Research Object Description

Indonesia is one of the countries with the most complex tobacco excise tax systems in the world. As a country with high cigarette consumption, the tobacco excise policy has a dual role, namely as a major source of state revenue and as a means of social control over tobacco product consumption. In the context of national fiscal policy, revenue from tobacco excise has consistently been one of the important pillars of state budget financing, especially in supporting development and public health programs.

Figure 4. 1 Map of the Republic of Indonesia



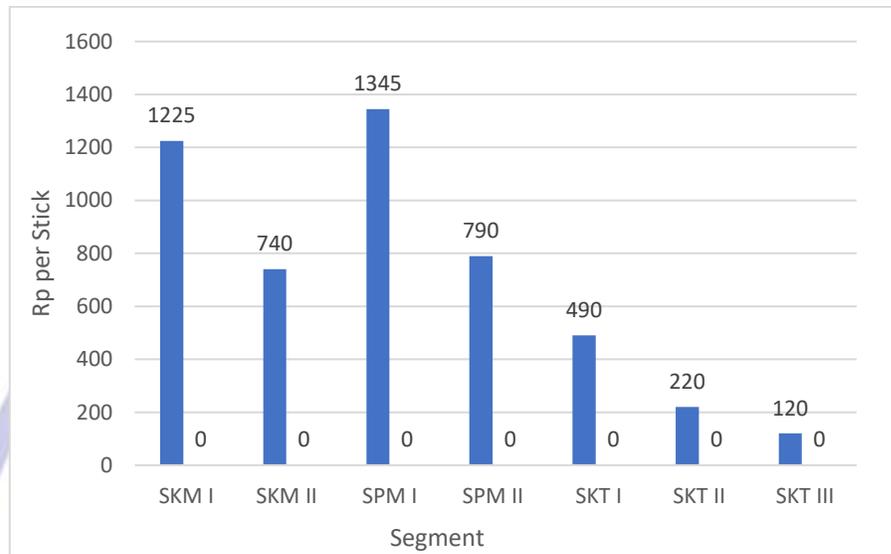
Source: detikNews, 2019

The object of this study is the Tobacco Excise Tax (*Cukai Hasil Tembakau*) revenue in Indonesia, which is a major component of the state revenue structure. Tobacco Excise consistently contributes more than 95% of national excise revenue each year (Ministry of Finance, 2024). This sector plays a strategic role not only as a source of state revenue, but also as a fiscal policy instrument to balance budgetary (revenue collection) and regulatory (control of cigarette consumption) functions. This study focuses on the effect of the tiered excise system on excise revenue in two main segments, namely Tier I (SKM I) and Tier II (SKM II), with GDP (current price) as a moderating variable. The tiered tariff structure in Indonesia is determined based on production volume and retail price, which reflects the segmentation between premium and economy products. The data used is quarterly time series data for the period 2017Q1 – 2024Q4 with 32 observations, sourced from the Ministry of Finance, BPS, and the Directorate General of Customs and Excise (DJBC).

4.1.1. Overview of Excise Revenue in Indonesia

Excise revenue is one of the main components of Indonesia's state revenue structure. Of the total national excise revenue, Tobacco Excise (CHT) consistently dominates with an average contribution of over 95% each year (Ministry of Finance, 2024). This dominance shows how important the tobacco industry (IHT) is as a pillar of national fiscal stability. In 2023, total excise revenue reached IDR217.99 trillion, of which IDR213.49 trillion (97.93%) came from (*Cukai Hasil Tembakau*), while the rest came from excise on ethyl alcohol and ethyl alcohol-containing beverages.

Figure 4. 2 Cigarette Excise Tariffs 2024



Source: Ministry of Finance, 2023

It can be seen that the highest excise tariff is applied to Machine-made Kretek Cigarettes Class I (SKM 1) at Rp1,225 per stick, followed by Machine-Rolled White Cigarette Class I (SPM 1) at Rp1,345 per stick. Meanwhile, the Machine-Rolled Kretek Cigarettes Class II (SKM 2) and Machine-Rolled With Cigarettes Class II (SPM 2) segments are subject to lower rates, at RP740 and RP790 per stick, respectively. Traditional labour-intensive products such as Hand-Rolled Kretek Cigarettes (SKT) are subject to much lower excise taxes, namely RP490 for SKT I, RP220 for SKT II, and RP120 for SKT III (Ministry of Finance, 2023).

4.2. Descriptive Statistics Analysis

4.2.1 Descriptive Statistics SKM Tier I

Table 4. 1 Descriptive Statistics Tier I

Variable	Obs	Mean	Median	Min	Max	Std. Dev
REV1	32	2.87E+13	3.08E+13	2.10E+12	4.15E+13	1.09E+13
TAX1	32	522.17	590.00	1.10	985.00	333.36
TAX1_SQ	32	380.316	348.100	1.21	970.225	301.651
PDBHB	32	4.53.160	4.042.982	3.288.172	5.674.930	750.225

Source: Secondary Data, Processed by E-views, 2026

The descriptive statistics for the Tier I model indicate that the average quarterly excise revenue (REV1) during 2017Q1–2024Q4 amounts to 2.87E+13 rupiah, with values ranging from 2.10E+12 to 4.15E+13. The relatively high standard deviation suggests considerable variation in revenue over time, likely reflecting policy adjustments and economic fluctuations. The average excise rate (TAX1) is approximately Rp 522 per stick, increasing progressively throughout the study period. The inclusion of the squared tax variable (TAX1_SQ) allows the model to capture potential non-linear effects consistent with the Laffer Curve hypothesis. Meanwhile, GDP at current prices (PDBHB) shows an upward trend, reflecting nominal economic growth and aggregate demand expansion over the sample period.

4.2.2 Descriptive Statistics SKM Tier II

Table 4. 2 Descriptive Statistics Tier II

Variable	Obs	Mean	Median	Min	Max	Std. Dev
REV2	30	6.37E+12	5.28E+12	1.17E+10	1.37E+13	4.58E+12
TAX2	30	1.369.07	600.00	350.00	3.675.00	1.418.63
TAX2_SQ	30	381.977	360.000	12.250	13.505.625	5.941.850
PDBHB	30	4.266.244	3.995.770	3.228.172	5.536.589	690.392

Source: Secondary Data, Processed by E-views, 2026

The descriptive statistics for the Tier II model, based on 30 quarterly observations, indicate that the average excise revenue amounts to 6.37E+12 rupiah, with values ranging from 1.17E+10 to 1.37E+13 rupiah. The excise rate (TAX2) shows substantial variation, with an average of Rp 1,369 per stick and a maximum value of Rp 3,675, reflecting the progressive excise restructuring over the sample period. The squared tax variable (TAX2_SQ) exhibits considerable dispersion, consistent with the quadratic specification employed to capture potential non-linear effects. Meanwhile, GDP at current prices (PDBHB) displays steady nominal growth, indicating expanding aggregate demand conditions during the study period.

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4.3. Analysis of SKM Tier I Model

4.3.1 Classical Assumption Test (Tier I)

Before proceeding with hypothesis testing, this study conducted a series of classical assumption tests to ensure that the regression model meets the criteria of the *Best Linear Unbiased Estimator* (BLUE) as stated in the Gauss-Markov theorem. These tests include the normality test, multicollinearity test, autocorrelation test, and heteroskedasticity test. Meeting these assumptions ensures that the Ordinary Least Squares (OLS) estimators remain efficient, consistent, and unbiased (Gujarati & Porter, 2009) (Wooldridge, 2016).

Normality Test Tier I

The normality of residuals was tested using the Jarque-Bera (JB) test to verify whether the model's residuals follow a normal distribution. The null hypothesis (H_0) states that residuals are normally distributed, while the alternative hypothesis (H_1), suggests otherwise. The result of the Jarque-Bera testing is as follows:

Table 4. 3 Normality Tier I Testing Result

Test	Statistic	Probability
Jarque-Bera Test	0.762424	0.686457

Source: Author, 2026

Based on the results of the residual normality test using the Jarque-Bera method, a Jarque-Bera statistic of 0.423515 with a probability value of 0.809161 was obtained. Since this probability is substantially greater than the 0.05 significance level, the null hypothesis (H_0) that residuals are normally distributed is not rejected. This means the regression model has fulfilled the normality assumption, indicating that the error terms are symmetrically distributed around a mean of zero.

Visually, the residual histogram supports this conclusion by showing a bell-shaped curve that closely approximates a normal distribution. The skewness value of 0.051683, which is near zero, indicates that the distribution is neither skewed left nor right. Meanwhile, the kurtosis value of 2.445968 is close to the ideal normal distribution kurtosis of 3. The mean residual value of approximately -1.105×10^{13} also suggests that model prediction errors are centred closely around zero, pointing to the absence of systematic bias in the model.

Overall, these results affirm that the interaction regression model satisfies the classical assumption of normality. This is essential because it ensures that the coefficient estimates produced by the model are BLUE (Best Linear Unbiased Estimator) under classical linear regression assumptions. As a result, statistical inference tests such as the t-test and F-test can be trusted to provide valid conclusions, supporting sound economic interpretations and policy recommendations based on the model.

Multicollinearity Test Tier I

Table 4. 4 Multicollinearity Tier I Result

Variable	Coefficient Variance	Centered VIF
TAX1	2.17E+21	97.71097
TAX1_SQ	2.07E+15	78.61682
PDBHB	4.81E+13	11.01271
C	1.42E+27	N/A

Source: Author, 2026

The Variance Inflation Factor (VIF) technique is used to perform the multicollinearity test. A VIF number of 10 or more shows possible multicollinearity issues, while a value below 10 generally denotes the lack of significant multicollinearity. VIF values are comparatively high, according to the estimation results, especially for the tax variable and its squared term. This suggests a high degree of correlation between the explanatory factors. However, in quadratic regression models, such a condition is logically expected. Since the squared term is theoretically derived from the base variable, adding a squared term (such as TAX1² or TAX2²) always results in a high correlation with its original variable. As a result, this model's high VIF ratings may not always correspond to model misspecification. The structural feature of polynomial regression models, which are intended to capture non-linear interactions, is instead reflected in it.

According to econometric theory, multicollinearity mostly distorts the standard errors of individual coefficient estimates, which reduces their accuracy. It does not, however, invalidate the overall model estimation or bias the estimators. The Ordinary Least Squares (OLS) estimators are unbiased and consistent when the Gauss-Markov assumptions hold true.

Using the Laffer Curve framework, the main goal of this quadratic specification is to determine whether and in which direction there is a non-linear relationship between excise tax rates and excise revenue, therefore the analysis concentrates on:

1. The indicators of the linear and quadratic coefficients.
2. The statistical relevance of the quadratic component.
3. The collective significance of the model (F-statistic).
4. The inferred curvature (U-shaped or inverted U-shaped correlation).

The high VIF values found in this study are therefore regarded as a reasonable and anticipated result of the quadratic model specification and do not call into question the reliability of the empirical results.

Autocorrelation Test

Table 4. 5 Autocorrelation Test Tier I Result

Statistical Test	Value
F-statistic	1.652074
Prob. F(2,24)	0.2127
Obs*R-Squared	3.872406
Prob. Chi-Square(2)	0.1443
Durbin-Watson Statistic	1.966437

Source: Author, 2026

The test results show an F-statistic of 1.652074 with a probability value of 0.2127 and an Obs*R-squared probability of 0.1443. Both probabilities exceed the 0.05 significance level, indicating no significant autocorrelation up to two lags. Therefore, the null hypothesis (no serial correlation) is accepted. In the test equation, neither RESID(-1) nor RESID(-2) is significant, which further supports the absence of a dynamic relationship between current and past residual. Additionally, the Durbin-Watson statistic is 1.966437, which is close to the ideal value of 2. This confirms that the models residuals are random and not serially correlated.

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Heteroscedasticity Test Tier I

Table 4. 6 Heteroscedasticity Tier I Test Result

Statistic Test	Value
F-statistic	3.450991
Prob. F(8,22)	0.0100
Obs*R-Squared	17.25220
Prob. Chi-Square(8)	0.0276
Scaled explained SS	9.383015
Prob. Chi-Square(8)	0.3110

Source: Author, 2026

The heteroskedasticity test is conducted at a 5 per cent significance level ($\alpha = 0.05$). The decision rule is as follows: if the probability value is less than 0.05, the null hypothesis of homoskedasticity is rejected; conversely, if the probability value is greater than or equal to 0.05, the null hypothesis cannot be rejected.

Based on the test results, the probability value of the F-statistic is **0.0100**, which is less than 0.05. Similarly, the probability value of the Obs*R-squared statistic is **0.0276**, which is also below the 5 per cent significance level. Therefore, the null hypothesis of homoskedasticity is rejected. These results indicate the presence of heteroskedasticity in the regression model.

From an econometric perspective, heteroskedasticity implies that the variance of the error term is not constant across observations. In other words, the dispersion of residuals varies with changes in the independent variables. This condition violates one of the classical assumptions of the Ordinary Least Squares (OLS) model, namely, homoskedasticity.

However, it is important to note that heteroskedasticity does not cause bias in the OLS coefficient estimates. The estimators remain unbiased and consistent under the Gauss-Markov framework. The primary issue arises in the estimation of standard errors, which may become inefficient and biased. As a consequence, statistical inference can be affected, potentially leading to misleading t-statistics and F-statistics, which may result in either over-rejecting or under-rejecting the null hypotheses.

4.3.2 Hypothesis Test Results (Tier I)

Simultaneous Test (F-test)

Table 4. 7 F-test Tier I Result

F-Statistic	Probability
8.504241	0.000387

Source: Author, 2026

The F-statistic value is 8.504241 with a probability of 0.000387. Since the probability value is significantly lower than the 5 per cent significance level (0.05), the null hypothesis that all slope coefficients are jointly equal to zero is rejected. This result indicates that the independent variables (TAX1, TAX1_SQ, and PDBHB) jointly have

a statistically significant effect on excise revenue. In other words, the quadratic regression model is statistically valid as a whole and provides explanatory power in explaining variations in revenue.

From an econometric standpoint, this confirms that the model is not spurious and that at least one explanatory variable significantly contributes to explaining the dependent variable.

Partial Test (t-Test)

Table 4. 8 t-Test Tier I Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
TAX1	1.28E+11	4.66E+10	2.745519	0.0106
TAX1_SQ	-1.09E+08	45530592	-2.403429	0.0234
PDBHB	25694285	6932314	3.706451	0.0010
C	-1.10E+14	3.77E+13	-2.925110	0.0069

Source: Author, 2026

The partial test evaluates the individual significance of each explanatory variable in influencing excise revenue. The estimation results indicate that the linear tax variable (TAX1) has a positive and statistically significant effect on excise revenue. With a coefficient of 1.28E+11, a t-statistic of 2.745519, and a probability value of 0.0106, which is below the 5 percent significance level, the null hypothesis that the coefficient equals zero is rejected. This finding implies that, at lower levels of taxation,

an increase in the excise tax rate leads to an increase in government revenue. Economically, this reflects the arithmetic effect of taxation, where higher rates initially expand fiscal revenue as long as the tax base remains relatively stable.

The quadratic term (TAX1_SQ) is also statistically significant, with a coefficient of $-1.09E+08$, a t-statistic of -2.403429 , and a probability value of 0.0234 . The negative sign of the quadratic coefficient, combined with the positive sign of the linear term, confirms the presence of an inverted U-shaped relationship between excise tax rates and excise revenue. This result is consistent with the Laffer Curve hypothesis, which states that revenue increases with higher tax rates up to a certain optimal point, beyond which further increases in tax rates lead to declining revenue due to contraction of the tax base.

Furthermore, the macroeconomic variable PDBHB (GDP at current price) exhibits a positive and statistically significant relationship with excise revenue. With a coefficient of $25,694,285$, a t-statistic of 3.706451 , and a probability value of 0.0010 , the variable significantly contributes to explaining variations in revenue. This finding suggests that higher levels of economic activity strengthen the government's revenue-generating capacity by expanding the taxable base. In other words, macroeconomic growth enhances the effectiveness of excise policy.

The constant term is also statistically significant, with a coefficient of $-1.10E+14$ and a probability value of 0.0069 . Although the economic interpretation of the intercept is limited in isolation, it represents the baseline level of excise revenue when all explanatory variables are hypothetically equal to zero.

4.3.3 Quadratic Relationship Analysis (Laffer Curve Tier I)

To examine whether the relationship between excise tax rates and excise revenue follows a non-linear pattern, this study employs a quadratic regression specification. The quadratic model incorporates both the linear term of the excise tax rate and its squared term, allowing the identification of curvature in the tax–revenue relationship. This approach is widely used in empirical studies testing the Laffer Curve hypothesis (Fullerton, 1982; Wanniski, 1978; Mankiw, 2021).

The theoretical foundation of this specification is derived from the Laffer Curve framework, which suggests that government revenue is zero at a zero tax rate and also approaches zero at an excessively high tax rate, implying the existence of an optimal revenue-maximising tax rate (Laffer, 2004; Varian, 2014). The relationship between tax rates and revenue is therefore expected to follow a concave (inverted-U) pattern.

The inclusion of the squared tax term enables the model to capture potential non-linear effects. An inverted U-shaped relationship consistent with the Laffer Curve is supported if:

1. The coefficient of the linear tax term (β_1) is positive; and
2. The coefficient of the squared tax term (β_2) is negative and statistically significant.

This configuration reflects the dominance of the arithmetic effect at lower tax rates and the economic effect at higher tax rates (Mankiw, 2021; Ebrill et al., 2001). The arithmetic effect implies that increasing tax rates mechanically raises revenue, holding the tax base constant.

In contrast, the economic effect recognises behavioural responses, where higher tax rates reduce consumption, production, or compliance, thereby shrinking the tax base.

The turning point of the quadratic function, representing the revenue-maximising tax rate, is calculated using the first derivative condition:

$$TAX^* = \frac{\beta_1}{2\beta_2} \quad (4.1)$$

If the estimated turning point lies within the observed range of tax rates, empirical evidence supports the presence of a Laffer-type relationship (Fullerton, 1982; Varian, 2014). Furthermore, macroeconomic conditions are controlled through GDP at current prices (PDBHB). Higher economic activity may expand the tax base and increase excise revenue; however, GDP functions as a shift variable rather than determining the curvature of the tax–revenue relationship (Gujarati & Porter, 2009).

Turning Point Estimation

To determine whether an optimal tax rate exists, this study calculates the turning point of the quadratic function. In a quadratic regression model, the turning point represents the tax rate at which excise revenue reaches either a maximum or a minimum, depending on the curvature of the function.

Given the quadratic specification:

$$REV1_t = \beta_0 + \beta_1 TAX1_t + \beta_2 TAX1_t^2 + \beta_3 PDBHB_t + \varepsilon_t \quad (4.2)$$

The turning point is obtained by taking the first derivative of revenue with respect to the tax rate and setting it equal to zero:

$$\frac{\partial REV}{\partial TAX} = \beta_1 + 2\beta_2 TAX = 0 \quad (4.3)$$

Solving for TAX yields:

$$TAX^* = \frac{-\beta_1}{(2\beta_2)} \quad (4.4)$$

This value represents the critical tax rate at which revenue changes direction (Varian, 2014; Gujarati & Porter, 2009).

Solving for TAX1:

$$TAX^* = \frac{-\beta_1}{(2\beta_2)} \quad (4.5)$$

Substituting the estimated coefficients:

$$TAX^* = -\frac{1.28 \times 10^{11}}{2(-1.09 \times 10^8)}$$

$$TAX^* = -\frac{1.28 \times 10^{11}}{-2.18 \times 10^8}$$

$$TAX^* = \frac{1.28}{2.18} \times 10^3$$

$$TAX^* \approx 0.587 \times 1000$$

$$TAX^* \approx 587$$

The economic interpretation of the turning point depends on the sign of the quadratic coefficient:

- If $\beta_2 < 0$ → the function is concave (inverted U-shape), and TAX^* represents the **revenue-maximising tax rate**, consistent with the Laffer Curve hypothesis (Laffer, 2004; Mankiw, 2021).
- If $\beta_2 > 0$ → the function is convex (U-shape), and TAX^* represents a **revenue-minimising tax rate**, meaning revenue initially decreases and then increases as tax rates rise.

For the Laffer Curve condition to hold, two requirements must be satisfied:

1. $\beta_1 > 0$
2. $\beta_2 < 0$

When these conditions are met and statistically significant, the relationship between tax rates and revenue follows an inverted U-shape, implying that revenue first increases with tax rates but eventually declines beyond the optimal threshold.

The estimation results indicate that the coefficient of $TAX1$ is positive and statistically significant ($\beta_1 = 1.28E+11$, $p < 0.05$), while the coefficient of the squared term $TAX1^2$ is negative and statistically significant ($\beta_2 = -1.09E+08$, $p < 0.05$). This

sign combination confirms the presence of a concave (inverted U-shaped) relationship between Tier I excise tax rates and excise revenue.

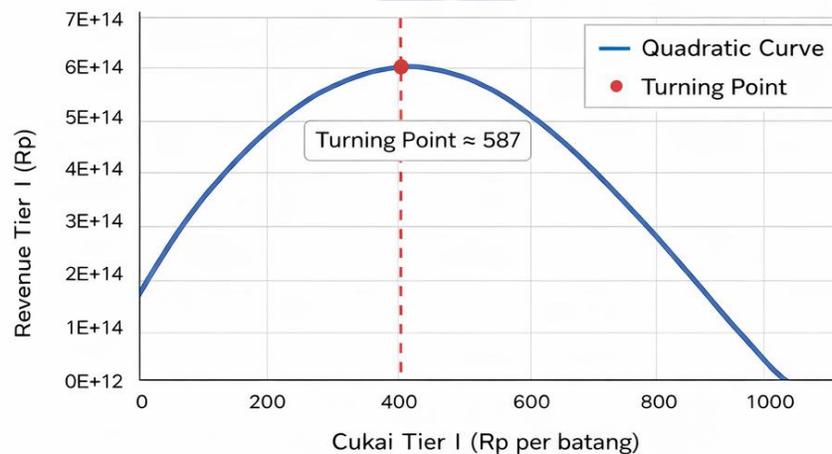
The positive linear coefficient suggests that, at lower levels of taxation, increases in excise rates lead to higher government revenue, reflecting the arithmetic effect of taxation. However, the negative and significant quadratic coefficient indicates that beyond a certain threshold, further increases in tax rates reduce excise revenue, consistent with the economic effect described in the Laffer Curve framework.

The turning point of the quadratic function is calculated using the formula $\frac{-\beta_1}{(2\beta_2)}$, resulting in an estimated revenue-maximising tax rate of approximately 587. This value represents the level of excise taxation at which Tier I revenue reaches its maximum. If the observed tax rates during the sample period fall below this threshold, the economy operates on the upward-sloping side of the Laffer Curve. Conversely, if tax rates exceed this value, revenue may begin to decline due to contraction in the tax base.

The statistical significance of both the linear and quadratic terms strengthens the robustness of the non-linear specification, confirming that the quadratic model provides a better representation of the tax–revenue dynamics compared to a simple linear model.

Laffer Curve Interpretation Tier I

Figure 4. 3 Laffer Curve-Type Relationship (Tier I)



Source: Author, 2026

The estimation results provide empirical evidence supporting the Laffer Curve hypothesis for SKM Tier I excise taxation in Indonesia. The positive and statistically significant coefficient of the linear tax term, combined with the negative and significant coefficient of the squared tax term, confirms the existence of an inverted U-shaped relationship between excise tax rates and excise revenue.

This pattern reflects the coexistence of two opposing mechanisms. At lower tax rates, the arithmetic effect dominates, whereby increases in tax rates mechanically raise government revenue. However, as tax rates continue to increase, the economic effect becomes stronger. Higher taxation reduces sales volume, encourages downtrading behavior, and potentially shrinks the effective tax base. When this contraction outweighs the arithmetic gain, total excise revenue begins to decline.

The estimated turning point of approximately 587 represents the revenue-maximising excise tax rate. This value indicates the threshold at which the marginal revenue effect of increasing tax rates becomes zero. Beyond this point, further tax increases may lead to diminishing revenue performance. This suggests that current excise rates are close to the revenue-maximising level, implying limited fiscal gains from further tax increases.

4.4 Analysis of SKM Tier II Model

4.4.1 Classical Assumption Test (Tier II)

Normality Test

Table 4.9 Normality Test Tier II Results

Test	Statistic	Probability
Jarque-Bera Test	1.956795	0.375913

Source: Author, 2026

The test results show a probability value of **0.375913**, which is greater than the 5 per cent significance level ($\alpha = 0.05$). Therefore, the null hypothesis stating that the residuals are normally distributed cannot be rejected. This finding indicates that the residuals of the Tier II regression model are statistically normally distributed. In other words, there is no significant deviation from normality in the error term.

From an econometric perspective, the fulfilment of the normality assumption is important to ensure the validity of statistical inference, particularly in relatively small samples. Since the residuals are normally distributed, the t-tests and F-tests used in the

quadratic regression analysis remain valid. Consequently, the estimation results of the Tier II model can be interpreted and relied upon for hypothesis testing purposes.

Multicollinearity Test Tier II

Table 4. 10 Multicollinearity Tier II Result

Variable	Coefficient Variance	Centered VIF
TAX2	1.70E+20	4192.444
TAX2_SQ	1.01E+13	6208.886
PDBHB	2.73E+12	704.6595

Source: Author, 2026

The estimation results for the Tier II model show that TAX2 and its squared term (TAX2_SQ) exhibit very large VIF values, exceeding 4000. At first glance, this suggests severe multicollinearity. However, from a theoretical and econometric standpoint, this condition is entirely expected in quadratic regression models. Since TAX2_SQ is mathematically defined as the square of TAX2, the two variables are inherently and structurally correlated. This high correlation is therefore a natural consequence of the polynomial specification rather than an indication of model misspecification.

In quadratic regression models, multicollinearity between a variable and its squared term is structural in nature. Importantly, this does not cause bias in the OLS estimators, nor does it invalidate the overall significance of the model. The presence of

structural multicollinearity does not alter the functional form or the identification of the non-linear (U-shaped or inverted U-shaped) relationship.

For the macroeconomic variable PDBHB, the centered VIF value of 18.54 indicates a relatively strong correlation with other explanatory variables. Nevertheless, such a magnitude can still be tolerated within the context of macroeconomic time-series data, where economic variables often exhibit trending behavior and interdependence.

From an econometric perspective, multicollinearity does not make the estimators biased; rather, it increases the variance of the estimated coefficients, which may reduce their statistical precision and potentially lower the t-statistics. However, it does not invalidate the model or its overall explanatory power.

Autocorrelation Test Tier II

Table 4. 11 Autocorrelation Tier II Results

Statistics Test	Value
F-Statistic	3.953887
Prob. F (2,25)	0.0322
Obs*R-Squared	7.449334
Prob. Chi-Square (2)	0.0241
Durbin-Watson stat	2.092123

Source: Author, 2026

The test results show a probability value of **0.0322** for the F-statistic and **0.0241** for the Chi-Square statistic. Since both probability values are lower than the 5 per cent significance level ($\alpha = 0.05$), the null hypothesis of no serial correlation is rejected.

This finding indicates that the regression model exhibits autocorrelation in the residuals up to the second lag. In other words, the error terms are not independent across time periods and display dynamic dependence.

Further evidence is observed from the auxiliary regression results. The first lag of the residual, $\text{RESID}(-1)$, has a coefficient of **0.4639** with a probability value of **0.0203**, indicating statistical significance at the 5 percent level. Similarly, the second lag, $\text{RESID}(-2)$, has a coefficient of **-0.3982** with a probability value of **0.0466**, which is also statistically significant. These results confirm that the autocorrelation originates from both the first and second lag of the residuals.

From an econometric perspective, autocorrelation commonly arises in time series data, particularly in quarterly macroeconomic datasets such as those used in this study. The presence of serial correlation does not bias the OLS coefficient estimates; however, it renders the standard errors inefficient. Consequently, hypothesis testing using conventional standard errors may become unreliable, potentially leading to incorrect inferences.

To address this issue, the model is corrected using heteroskedasticity and autocorrelation consistent (HAC) standard errors, specifically the Newey–West correction.

This approach ensures that the estimated standard errors remain robust to both heteroskedasticity and autocorrelation, thereby preserving the consistency of the estimators and the validity of statistical inference.

Heteroscedasticity Test Tier II

Table 4. 12 Heteroscedasticity Tier II Results

Statistic Test	Value
F-Statistic	0.070288
Prob. F(3,27)	0.9753
Obs*R-Squared	0.240227
Scaled explained SS	0.085236
Prob. F (3,27)	0.9753
Prob. Chi-Square (3)	0.9708
Prob. Chi-Square (3)	0.9935

Source: Author, 2026

Based on the estimation results, the probability values obtained are 0.9753 for the F-statistic, 0.9708 for the Chi-Square statistic, and 0.9935 for the Scaled Explained Sum of Squares. All probability values are substantially higher than the 5 per cent significance level ($\alpha = 0.05$). Since all p-values exceed 0.05, the null hypothesis of homoscedastic residuals cannot be rejected. This indicates that there is no evidence of heteroskedasticity in the Tier II regression model. In other words, the variance of the residuals remains constant across observations.

From an econometric perspective, the absence of heteroskedasticity implies that one of the classical assumptions of the Ordinary Least Squares (OLS) estimator is satisfied. Consequently, the OLS estimators are not only unbiased and consistent but also efficient (BLUE), and the standard errors are reliable for hypothesis testing.

Therefore, the t-tests and F-tests conducted in the Tier II quadratic model can be considered statistically valid.

4.4.2 Hypothesis Test Result

Simultaneous Test (F-test)

Table 4. 13 F-test Tier II Results

F Statistic	Probability
82.20429	0.000000

Source: Author, 2026

The estimation results show an F-statistic value of 82.20 with a probability value of 0.0000. Since the probability value is significantly lower than the 5 per cent significance level ($\alpha = 0.05$), the null hypothesis that all slope coefficients are jointly equal to zero is rejected. This result indicates that the independent variables namely the excise tax rate (TAX2), its quadratic term (TAX2²), and GDP at current prices (PDBHB), jointly have a statistically significant effect on Tier II cigarette excise revenue. In other words, the model is statistically meaningful and capable of explaining variations in excise revenue.

Furthermore, the coefficient of determination (R^2) is 0.9013, while the Adjusted R^2 is 0.8904. This implies that approximately 89.04 per cent of the variation in Tier II excise revenue can be explained by variations in the excise tax rate, its quadratic effect, and macroeconomic conditions (PDBHB). The remaining 10.96 per cent is explained by other factors not included in the model.

From an econometric perspective, an Adjusted R^2 of 0.8904 is considered very strong for macroeconomic time series data, indicating that the quadratic specification provides a high explanatory power and a good model fit.

Partial Test (t-Test)

Table 4. 14 t-Test Tier II Result

Variable	Coefficient	Std.Error	t-Statistic	Prob.
TAX2	-5.25E+10	1.30E+10	-4.032594	0.0004
TAX2_SQ	12884525	1.30E+10	-4.032594	0.0004
PDBHB	12471803	1652879	7.545503	0.0000
C	-2.51E+13	2.30E+12	-10.91484	0.0000

Source: Author, 2026

The linear tax variable (TAX2) has a coefficient of **-5.25E+10**, with a t-statistic of **-4.032594** and a probability value of **0.0004**, which is statistically significant at the 5 percent level. The negative sign indicates that, holding other variables constant, an increase in the Tier II excise tax rate reduces excise revenue. This suggests that the current tax rate may already lie beyond the revenue-maximizing point, consistent with the downward-sloping side of the Laffer Curve.

Second, the quadratic term (TAX2_SQ) has a coefficient of **12,884,525**, with a probability value of **0.0004**, indicating statistical significance. The positive coefficient of the squared term, combined with the negative linear term, implies a **U-shaped relationship** between the Tier II excise rate and excise revenue. This means that at

lower levels of taxation, increases in the tax rate may reduce revenue, but beyond a certain turning point, further increases could potentially raise revenue again. Econometrically, the joint significance of the linear and quadratic terms confirms the presence of a non-linear relationship between tax rates and revenue.

Third, the macroeconomic variable PDBHB (GDP at current prices) has a coefficient of **12,471,803**, a t-statistic of **7.545503**, and a probability value of **0.0000**, indicating strong statistical significance. The positive sign suggests that higher economic activity increases excise revenue. This finding implies that macroeconomic growth strengthens the tax base and enhances the government's revenue-generating capacity in the Tier II segment.

The constant term (C) is negative and statistically significant, with a coefficient of **-2.51E+13** and a probability value of **0.0000**. Although the economic interpretation of the intercept is limited, its statistical significance indicates that the baseline level of revenue, when all explanatory variables are hypothetically zero, is significantly different from zero.

4.4.3 Quadratic Relationship Analysis

Turning Point Estimation Tier II

To determine whether an optimal tax rate exists, this study calculates the turning point of the quadratic function. In a quadratic regression model, the turning point represents the tax rate at which excise revenue reaches either a maximum or a minimum, depending on the curvature of the function.

Given the quadratic specification:

$$REV2_t = \beta_0 + \beta_1 TAX2_t + \beta_2 TAX2_t^2 + \beta_3 PDBHB_t + \varepsilon_t \quad (4.6)$$

The turning point is obtained by taking the first derivative of revenue with respect to the tax rate and setting it equal to zero:

$$\frac{\partial REV}{\partial TAX} = \beta_1 + 2\beta_2 TAX = 0 \quad (4.7)$$

Solving for TAX yields:

$$TAX^* = \frac{-\beta_1}{(2\beta_2)} \quad (4.8)$$

This value represents the critical tax rate at which revenue changes direction (Varian, 2014; Gujarati & Porter, 2009).

Solving for TAX2:

$$TAX^* = -\frac{-5.25 \times 10^{10}}{2(1.2884525 \times 10^7)}$$

$$TAX^* = \frac{5.25 \times 10^{10}}{2.576905 \times 10^7}$$

$$TAX^* \approx \frac{5.25}{2.5769} \times 10^3$$

$$TAX^* \approx 2037$$

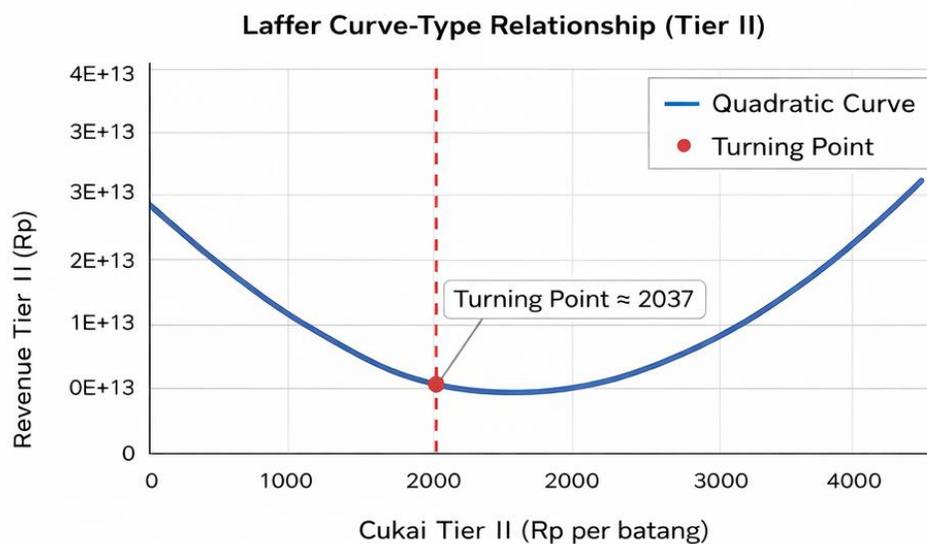
The estimated coefficients for Tier II indicate a negative and statistically significant linear tax term ($\beta_1 = -5.25E+10$) and a positive and significant quadratic term ($\beta_2 = 1.29E+07$). This sign configuration implies a convex (U-shaped) relationship between excise tax rates and revenue, rather than the inverted U-shaped relationship predicted by the traditional Laffer Curve.

The calculated turning point is approximately 2037. However, since the quadratic coefficient is positive, this value represents a revenue-minimizing tax rate rather than a revenue-maximising one. This suggests that revenue initially decreases as tax rates increase, but beyond a certain level, revenue begins to rise again.

Therefore, the empirical evidence for Tier II does not support the conventional Laffer Curve hypothesis.

Laffer Curve Interpretation Tier II

Figure 4. 4 Laffer Curve-Type Relationship (Tier II)



Source: Author, 2026

The estimation results for Tier II do not support the traditional Laffer Curve hypothesis. The linear tax coefficient is negative and statistically significant, while the

squared term is positive and significant, indicating a convex (U-shaped) relationship between excise tax rates and revenue.

This sign configuration suggests that, at lower levels of taxation, increases in Tier II excise rates are associated with a reduction in revenue. However, beyond a certain threshold, revenue begins to increase as tax rates rise further. The calculated turning point represents a revenue-minimizing tax rate rather than a revenue-maximizing one. These findings imply that the revenue dynamics of Tier II differ from the classical Laffer mechanism. Unlike Tier I, where revenue behavior follows the expected inverted U-pattern, Tier II appears to be influenced by structural market factors, including substitution effects and downtrading behavior within the multi-tier excise system.

Therefore, the Laffer Curve framework does not fully explain the tax–revenue relationship in Tier II, highlighting the asymmetric impact of excise policy across different market segments.

4.5. Result Discussion

4.5.1 The Impact Quadratic Relationship between Excise Tax and Revenue

For Tier I, the estimation results show that the coefficient of TAX1 is positive and statistically significant, while the coefficient of TAX1_SQ is negative and statistically significant at the 5 percent level. The combination of a positive linear term ($\beta_1 > 0$) and a negative squared term ($\beta_2 < 0$) indicates an inverted U-shaped relationship between the excise tax rate and excise revenue.

This finding is consistent with the Laffer Curve hypothesis, which posits that tax revenue initially increases with higher tax rates due to the arithmetic effect, but beyond a certain threshold, further tax increases reduce revenue because of behavioral responses that shrink the tax base (Fullerton, 1982; Mankiw, 2021). Theoretical contributions by Wanniski (1978) and empirical discussions by Trabandt and Uhlig (2011) also demonstrate that revenue-maximizing tax rates exist under certain elasticity conditions. In the context of tobacco taxation, similar non-linear patterns have been documented in countries where demand becomes more elastic at higher price levels due to substitution, illicit trade, or consumption reduction (Chaloupka et al., 2019; Laffer, 2004). Therefore, the Tier I result aligns with both theoretical fiscal models and empirical tobacco tax literature. Hence, for Tier I, H1 is supported.

In contrast, for Tier II, the linear coefficient of TAX2 is negative and statistically significant, while the squared term TAX2_SQ is positive and significant. This sign combination ($\beta_1 < 0$; $\beta_2 > 0$) produces a U-shaped relationship rather than an inverted U-shaped curve.

This suggests that at lower tax levels, increases in the Tier II excise rate are associated with declining revenue, but beyond a certain level, revenue begins to increase again. Such deviations from the classical Laffer pattern may occur in segmented markets with heterogeneous consumer groups and differential price sensitivity (Cremer & Gahvari, 1993). In multi-tier excise systems, cross-tier substitution and downtrading behavior can distort the conventional tax-revenue curve,

particularly when consumers shift from higher-tax to lower-tax products (Ross & Chaloupka, 2006; World Bank, 2017).

4.5.2 The Impact of Differences between Tier I and Tier II

The empirical results clearly confirm this hypothesis. Tier I exhibits an inverted U-shaped curve consistent with the traditional Laffer framework, whereas Tier II demonstrates a U-shaped pattern.

This divergence can be explained by structural differences inherent in multi-tier excise systems. In segmented tobacco markets, different product tiers face distinct demand elasticities, consumer profiles, and substitution patterns. As highlighted by Chaloupka et al. (2019), cigarette demand responses to tax increases vary significantly across price segments, particularly in countries with differentiated product categories. Higher-priced segments often exhibit stronger behavioral responses at elevated tax levels, leading to potential revenue-maximizing thresholds consistent with Laffer-type dynamics.

In contrast, lower-tier or mid-tier segments may experience complex substitution effects, including downtrading and cross-tier switching, which distort the conventional tax-revenue relationship (Ross & Chaloupka, 2006; World Bank, 2017). When consumers shift from higher-tax to lower-tax products within a multi-layer structure, the aggregate revenue response may no longer follow a standard inverted U-shape.

Moreover, Slemrod (1998) and Keen (2012) emphasize that tax system design significantly affects revenue efficiency. In multi-rate or tiered excise regimes, heterogeneous tax bases can produce differentiated revenue elasticities across categories. This implies that the revenue-maximizing tax rate may vary across segments rather than being uniform.

4.5.3 The Effect of GDP (current price) on Excise Revenue

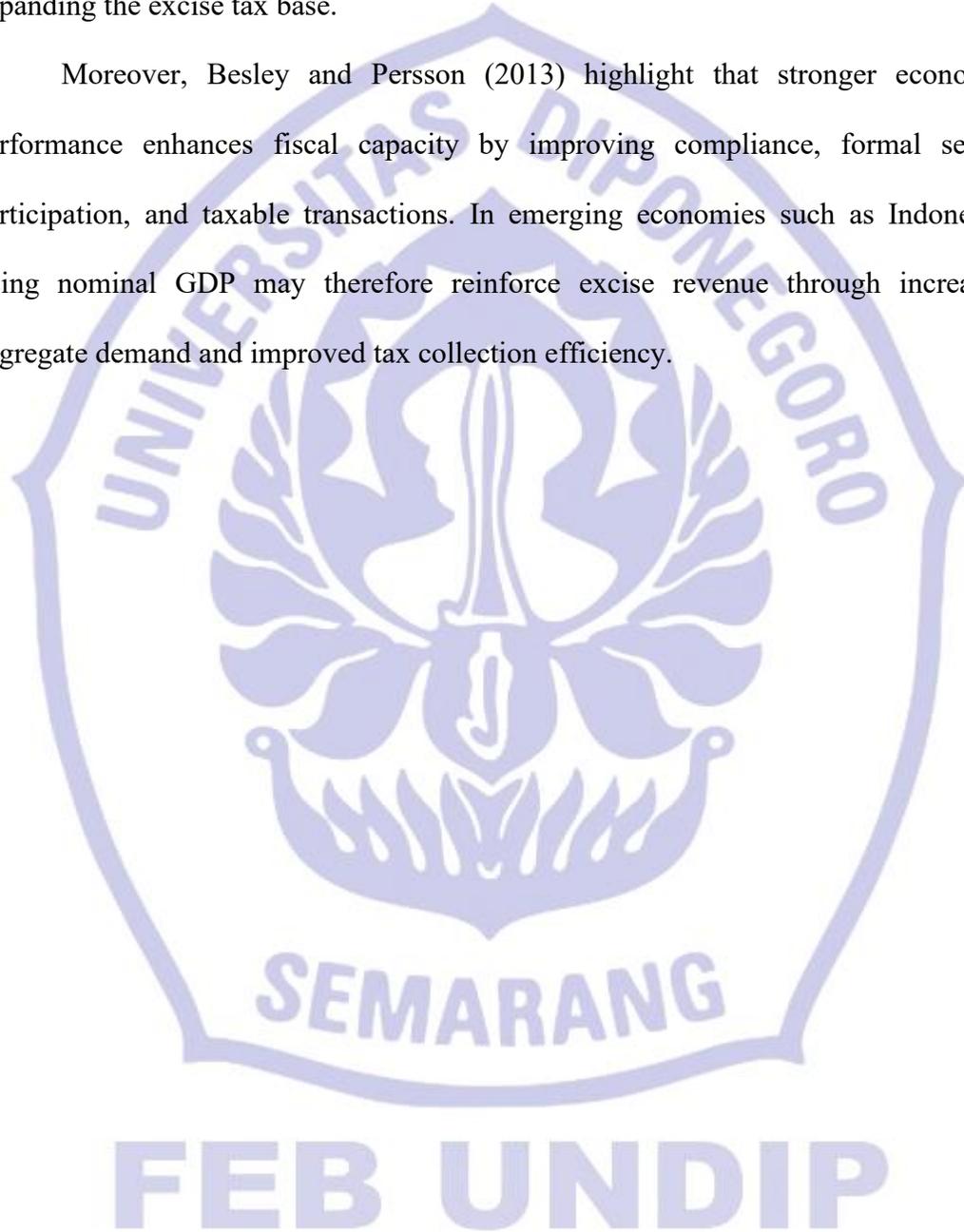
The regression results indicate that PDBHB has a positive and statistically significant coefficient in both Tier I and Tier II models. This implies that higher nominal economic activity is associated with increased excise revenue.

From a macroeconomic perspective, this finding is consistent with fiscal theory, which states that tax revenue is positively related to the level of economic activity. Musgrave and Musgrave (1989) argue that as national income expands, the tax base broadens, leading to higher government revenue even without changes in statutory tax rates.

Similarly, Tanzi (1987) emphasizes that revenue performance is strongly linked to nominal GDP growth, particularly in systems where taxes are levied on consumption and production activities. In the context of excise taxation, tobacco consumption is influenced not only by price but also by income levels. Empirical studies have shown that cigarettes often exhibit positive income elasticity, particularly in developing countries (Chaloupka & Warner, 2000; Gallet & List, 2003). As household income

increases, consumption may rise or become less sensitive to price increases, thereby expanding the excise tax base.

Moreover, Besley and Persson (2013) highlight that stronger economic performance enhances fiscal capacity by improving compliance, formal sector participation, and taxable transactions. In emerging economies such as Indonesia, rising nominal GDP may therefore reinforce excise revenue through increased aggregate demand and improved tax collection efficiency.



CHAPTER V

CONCLUSION

5.1. Conclusion

This study examines the non-linear relationship between excise tax rates and excise revenue within Indonesia's multi-tier cigarette excise system, focusing on Machine-Made Cigarettes (SKM) Tier I and Tier II over the period 2017–2024. Using a quadratic regression approach, this research evaluates whether revenue responses to tax changes follow a Laffer-type pattern and whether the dynamics differ across tiers.

The empirical findings confirm the existence of a quadratic relationship between excise tax rates and excise revenue. For Tier I, the results reveal a positive linear coefficient and a negative squared coefficient, indicating an inverted U-shaped relationship consistent with the Laffer Curve hypothesis. This suggests that excise revenue initially increases with higher tax rates due to the arithmetic effect but may decline beyond an optimal threshold as the economic effect through reduced consumption or behavioral responses dominates. In contrast, Tier II exhibits a U-shaped relationship, as indicated by a negative linear coefficient and a positive squared term. This finding suggests that the tax-revenue mechanism in the lower-tier segment differs structurally from Tier I. The result reflects heterogeneity within Indonesia's multi-tier excise system, where substitution effects, downtrading behavior, and differential demand elasticities influence revenue outcomes.

Furthermore, GDP at current prices (PDBHB) is found to have a positive and statistically significant effect on excise revenue in both tiers. This implies that macroeconomic expansion strengthens the government's revenue-generating capacity by broadening the tax base and increasing aggregate consumption.

5.2. Research Limitation

First, the analysis is based on quarterly time series data covering the period 2017–2024, resulting in a relatively limited number of observations. Although sufficient for quadratic regression analysis, a longer time horizon could provide more robust identification of long-run tax-revenue dynamics and structural shifts in the excise system.

Second, the model employs a quadratic specification to capture non-linear relationships between excise tax rates and revenue. While this approach allows identification of turning points consistent with the Laffer framework, it assumes a symmetric polynomial structure. In reality, tax-revenue dynamics may involve more complex behavioral responses, such as asymmetric adjustments, structural breaks, or regime shifts that are not fully captured by a second-degree polynomial model.

Third, this study focuses exclusively on legal excise revenue and does not explicitly incorporate illicit cigarette trade, tax avoidance behavior, or compliance dynamics. Prior literature suggests that high excise rates may stimulate informal market activity, which could alter the observed revenue response (Chaloupka et al., 2019;

World Bank, 2017). The absence of direct measures of illicit trade may therefore limit the completeness of the revenue elasticity estimation.

Fourth, GDP at current prices (PDBHB) is used as a proxy for macroeconomic conditions. While this variable captures nominal economic scale and is consistent with nominal excise revenue data, it does not disentangle real economic growth from inflationary effects. Future studies could incorporate real GDP, inflation adjustments, or per capita income measures to examine alternative macroeconomic channels.

Fifth, the study analyzes Tier I and Tier II separately but does not explicitly model cross-tier substitution effects using a structural demand framework. The observed differences between tiers may reflect underlying substitution behavior that would require micro-level consumption data or panel-based analysis to estimate more precisely.

Despite these limitations, the findings provide meaningful insights into the non-linear and tier-specific nature of excise revenue dynamics in Indonesia's multi-layered tax system.



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APPENDIX

Appendix 1. Data on Research Variables

Year	REV (1)	REV (2)	TAX (1)	TAX (2)	PDBHB
2017Q1	2690906460000.00	1396416295200.00	530	350	3.228.172.20
2017Q2	2096778156000.00	1323597524400.00	530	350	3.366.787.30
2017Q3	2401987560000.00	1761966770400.00	530	350	3.504.138.50
2017Q4	2562072894000.00	1863112114200.00	530	350	3.490.727.70
2018Q1	23626258776000.00	2945577879000.00	590	367.5	3.510.363.10
2018Q2	33048876432000.00	3777494937000.00	590	367.5	3.686.836.40
2018Q3	31272196098000.00	4492785279000.00	590	367.5	3.842.343.00
2018Q4	36849928422000.00	4319508927000.00	590	367.5	3.799.213.50
2019Q1	28595030742000.00	4196654898000.00	590	367.5	3.782.618.30
2019Q2	30628282134000.00	4061582640000.00	590	367.5	3.964.074.70

2019Q3	33250674132000.00	4061582640000.00	590	367.5	4.067.358.00
2019Q4	38548741146000.00	6059293668000.00	590	367.5	4.018.606.20
2020Q1	34896826020000.00	11677047300.00	740	463	3.923.347.90
2020Q2	26023976640000.00	13865747700.00	740	463	3.690.742.20
2020Q3	29565804600000.00	15769207500.00	740	463	3.897.851.90
2020Q4	35713806000000.00	18283937100.00	740	463	3.931.411.20
2021Q1	30634032636000.00	7561864602000.00	740	463	3.972.933.00
2021Q2	32781104988000.00	8558799313500.00	740	463	4.178.022.00
2021Q3	36191981158500.00	9410671393500.00	740	463	4.327.383.90
2021Q4	40089951292500.00	11049040548000.00	740	463	4.498.412.50
2022Q1	40618457805000.00	10625935320000.00	985	600	4.508.662.50
2022Q2	27955230825000.00	9228117960000.00	985	600	4,898,031.80
2022Q3	35969078535000.00	10145487420000.00	985	600	5.066.968.20
2022Q4	41534439840000.00	10205630280000.00	985	600	5.114.797.40

2023Q1	30145957474500.00	10147156378200.00	1.101	669	5.071.497.20
2023Q2	26940998772000.00	12204766094400.00	1.101	669	5.223.290.30
2023Q3	30557028706200.00	13718360397600.00	1.101	669	5.294.903.30
2023Q4	33689520249300.00	13243079115000.00	1.101	669	5.302.657.70
2024Q1	31009193318400.00	11543546707200.00	1.231	746	5.288.576.60
2024Q2	28027725105600.00	13077983066400.00	1.231	746	5.536.588.50
2024Q3	28171868065800.00	12945764712000.00	1.231	746	5.638.869.10
2024Q4	31836471850200.00	13313868042600.00	1.231	746	5.674.929.80

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Appendix 2. Regression Test Tier 1

Dependent Variable: REV1
 Method: Least Squares
 Date: 02/04/26 Time: 20:47
 Sample (adjusted): 2017Q1 2024Q3
 Included observations: 31 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.10E+14	3.77E+13	-2.925110	0.0069
TAX1	1.28E+11	4.66E+10	2.745519	0.0106
TAX1_SQ	-1.09E+08	45530592	-2.403429	0.0234
PDBHB	25694285	6932314.	3.706451	0.0010
R-squared	0.485839	Mean dependent var	2.86E+13	
Adjusted R-squared	0.428710	S.D. dependent var	1.11E+13	
S.E. of regression	8.39E+12	Akaike info criterion	62.47465	
Sum squared resid	1.90E+27	Schwarz criterion	62.65968	
Log likelihood	-964.3571	Hannan-Quinn criter.	62.53497	
F-statistic	8.504241	Durbin-Watson stat	0.822490	
Prob(F-statistic)	0.000387			

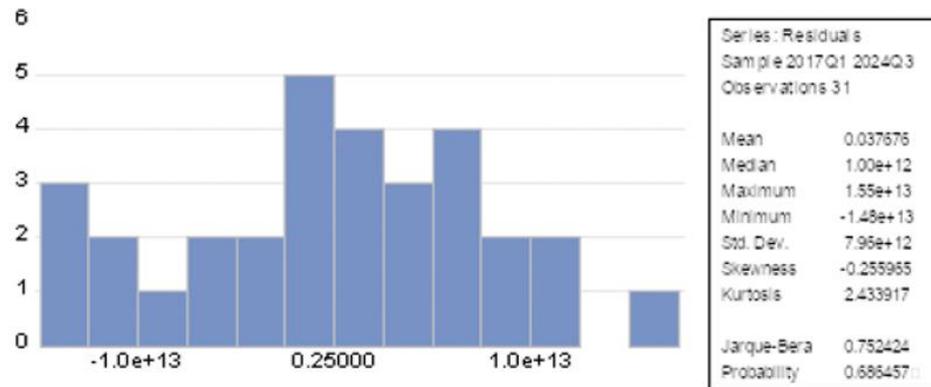


Appendix 3. Descriptive Statistic Tier 1

	REV1	TAX1	TAX1_SQ	PDBHB
Mean	2.87E+13	522.1665	380316.0	4353160.
Median	3.08E+13	590.0000	348100.0	4042982.
Maximum	4.15E+13	985.0000	970225.0	5674930.
Minimum	2.10E+12	1.101000	1.212201	3228172.
Std. Dev.	1.09E+13	333.3631	301651.0	750254.8
Skewness	-1.598348	-0.574675	0.494715	0.377589
Kurtosis	4.628264	2.133197	2.647970	1.743806
Jarque-Bera	17.16014	2.763139	1.470531	2.864424
Probability	0.000188	0.251184	0.479378	0.238780
Sum	9.18E+14	16709.33	12170111	1.39E+08
Sum Sq. Dev.	3.71E+27	3445060.	2.82E+12	1.74E+13
Observations	32	32	32	32



Appendix 4. Normality Test Tier 1



Appendix 5. Multicollinearity Result Tier 1

Variance Inflation Factors
Date: 02/05/26 Time: 17:59
Sample: 2017Q1 2024Q4
Included observations: 31

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	1.42E+27	625.1388	NA
TAX1	2.17E+21	375.7279	97.71097
TAX1_SQ	2.07E+15	219.2182	78.61682
PDBHB	4.81E+13	418.4811	11.01271



Appendix 6. Autocorrelation Test Tier 1

Breusch-Godfrey Serial Correlation LM Test:
Null hypothesis: No serial correlation at up to 2 lags

F-statistic	6.171554	Prob. F(2,25)	0.0066
Obs*R-squared	10.24651	Prob. Chi-Square(2)	0.0060

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 02/06/26 Time: 15:40
Sample: 2017Q1 2024Q3
Included observations: 31
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-3.75E+12	3.29E+13	-0.114031	0.9101
TAX1	5.52E+09	4.06E+10	0.136115	0.8928
TAX1_SQ	-4799185.	39588032	-0.121228	0.9045
PDBHB	589777.5	6063327.	0.097270	0.9233
RESID(-1)	0.665271	0.198393	3.353300	0.0025
RESID(-2)	-0.192459	0.205947	-0.934510	0.3590
R-squared	0.330532	Mean dependent var	0.037676	
Adjusted R-squared	0.196639	S.D. dependent var	7.96E+12	
S.E. of regression	7.14E+12	Akaike info criterion	62.20241	
Sum squared resid	1.27E+27	Schwarz criterion	62.47996	
Log likelihood	-958.1374	Hannan-Quinn criter.	62.29289	
F-statistic	2.468622	Durbin-Watson stat	1.923247	
Prob(F-statistic)	0.059905			

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Appendix 7. Heteroscedasticity Test

Heteroskedasticity Test: White
Null hypothesis: Homoskedasticity

F-statistic	3.450991	Prob. F(8,22)	0.0100
Obs*R-squared	17.25220	Prob. Chi-Square(8)	0.0276
Scaled explained SS	9.383015	Prob. Chi-Square(8)	0.3110

Test Equation:

Dependent Variable: RESID^2

Method: Least Squares

Date: 02/05/26 Time: 18:05

Sample: 2017Q1 2024Q3

Included observations: 31

Collinear test regressors dropped from specification

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	6.50E+27	8.01E+27	0.811356	0.4259
TAX1^2	-9.60E+21	6.13E+22	-0.156623	0.8770
TAX1*TAX1_SQ	2.40E+19	6.93E+19	0.346137	0.7325
TAX1*PDBHB	2.18E+18	3.40E+18	0.640109	0.5287
TAX1	-5.01E+24	2.51E+25	-0.199653	0.8436
TAX1_SQ^2	-9.31E+15	3.05E+16	-0.305394	0.7629
TAX1_SQ*PDBHB	-2.19E+15	3.33E+15	-0.658194	0.5172
PDBHB^2	2.24E+14	2.68E+14	0.834870	0.4128
PDBHB	-2.41E+21	2.93E+21	-0.822642	0.4195

R-squared	0.556522	Mean dependent var	6.14E+25
Adjusted R-squared	0.395258	S.D. dependent var	7.47E+25
S.E. of regression	5.81E+25	Akaike info criterion	121.7232
Sum squared resid	7.42E+52	Schwarz criterion	122.1396
Log likelihood	-1877.710	Hannan-Quinn criter.	121.8590
F-statistic	3.450991	Durbin-Watson stat	2.270734
Prob(F-statistic)	0.010030		

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Appendix 8. Regression Result Tier II

Dependent Variable: REV2
 Method: Least Squares
 Date: 02/04/26 Time: 20:48
 Sample (adjusted): 2017Q1 2024Q3
 Included observations: 31 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-2.51E+13	2.30E+12	-10.91484	0.0000
TAX2	-5.25E+10	1.30E+10	-4.032594	0.0004
TAX2_SQ	12884525	3178210.	4.054020	0.0004
PDBHB	12471803	1652879.	7.545503	0.0000
R-squared	0.901320	Mean dependent var		6.58E+12
Adjusted R-squared	0.890356	S.D. dependent var		4.66E+12
S.E. of regression	1.54E+12	Akaike info criterion		59.08622
Sum squared resid	6.42E+25	Schwarz criterion		59.27125
Log likelihood	-911.8364	Hannan-Quinn criter.		59.14653
F-statistic	82.20429	Durbin-Watson stat		1.315972
Prob(F-statistic)	0.000000			

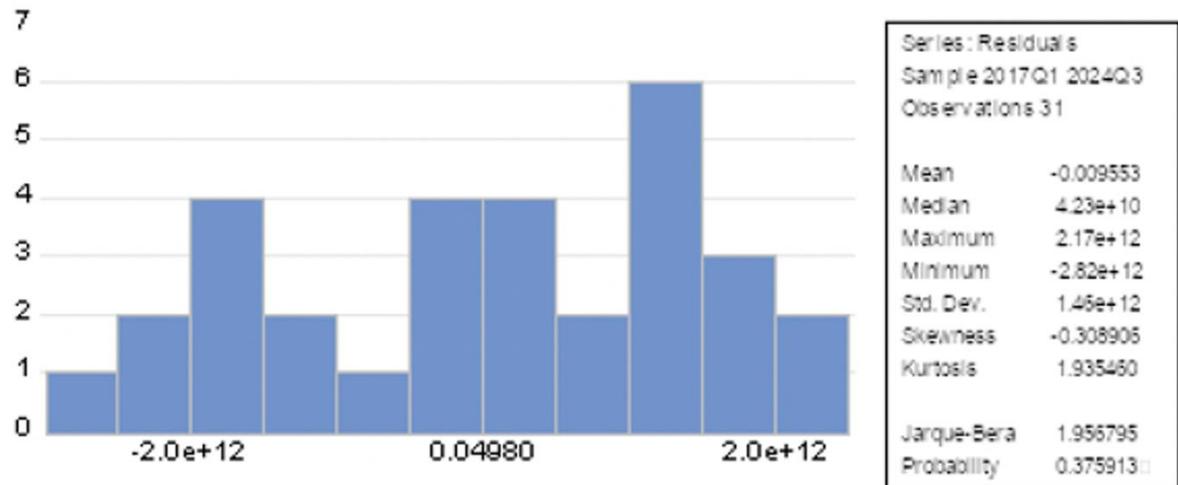


Appendix 9. Descriptive Statistics Tier II

	REV2	TAX2	TAX2_SQ	PDBHB
Mean	6.37E+12	1369.067	3819774.	4266244.
Median	5.28E+12	600.0000	360000.0	3995770.
Maximum	1.37E+13	3675.000	13505625	5536589.
Minimum	1.17E+10	350.0000	122500.0	3228172.
Std. Dev.	4.58E+12	1418.631	5941850.	690392.0
Skewness	0.071493	1.034738	1.053910	0.432148
Kurtosis	1.585905	2.101082	2.112793	1.819633
Jarque-Bera	2.525138	6.363482	6.537552	2.675344
Probability	0.282926	0.041513	0.038053	0.262456
Sum	1.91E+14	41072.00	1.15E+08	1.28E+08
Sum Sq. Dev.	6.09E+26	58362922	1.02E+15	1.38E+13
Observations	30	30	30	30



Appendix 10. Normality Test Tier II



Appendix 11. Multicollinearity Test Tier II

Variance Inflation Factors
Date: 02/07/26 Time: 18:20
Sample: 2017Q1 2024Q4
Included observations: 31

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	5.31E+24	69.20018	NA
TAX2	1.70E+20	8218.766	4192.444
TAX2_SQ	1.01E+13	6208.886	4392.272
PDBHB	2.73E+12	704.6595	18.54376



Appendix 12. Autocorrelation Test Tier II

Breusch-Godfrey Serial Correlation LM Test:
Null hypothesis: No serial correlation at up to 2 lags

F-statistic	3.953887	Prob. F(2,25)	0.0322
Obs*R-squared	7.449334	Prob. Chi-Square(2)	0.0241

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 02/07/26 Time: 18:11
Sample: 2017Q1 2024Q3
Included observations: 31
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-9.90E+11	2.14E+12	-0.463211	0.6472
TAX2	-6.06E+09	1.20E+10	-0.504084	0.6186
TAX2_SQ	1493868.	2934363.	0.509095	0.6152
PDBHB	824108.8	1532966.	0.537591	0.5956
RESID(-1)	0.463932	0.187220	2.478007	0.0203
RESID(-2)	-0.398238	0.190239	-2.093357	0.0466

R-squared	0.240301	Mean dependent var	-0.009553
Adjusted R-squared	0.088361	S.D. dependent var	1.46E+12
S.E. of regression	1.40E+12	Akaike info criterion	58.94042
Sum squared resid	4.88E+25	Schwarz criterion	59.21796
Log likelihood	-907.5765	Hannan-Quinn criter.	59.03089
F-statistic	1.581555	Durbin-Watson stat	2.092123
Prob(F-statistic)	0.201696		

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Appendix 13. Heteroscedasticity Test Tier II

Heteroskedasticity Test: Breusch-Pagan-Godfrey
 Null hypothesis: Homoskedasticity

F-statistic	0.070288	Prob. F(3,27)	0.9753
Obs*R-squared	0.240227	Prob. Chi-Square(3)	0.9708
Scaled explained SS	0.085236	Prob. Chi-Square(3)	0.9935

Test Equation:
 Dependent Variable: RESID^2
 Method: Least Squares
 Date: 02/07/26 Time: 18:02
 Sample: 2017Q1 2024Q3
 Included observations: 31

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.42E+24	3.19E+24	1.071398	0.2935
TAX2	3.08E+21	1.81E+22	0.170301	0.8660
TAX2_SQ	-7.54E+17	4.41E+18	-0.171167	0.8654
PDBHB	-6.15E+17	2.29E+18	-0.268384	0.7904

R-squared	0.007749	Mean dependent var	2.07E+24
Adjusted R-squared	-0.102501	S.D. dependent var	2.04E+24
S.E. of regression	2.14E+24	Akaike info criterion	115.0020
Sum squared resid	1.23E+50	Schwarz criterion	115.1870
Log likelihood	-1778.531	Hannan-Quinn criter.	115.0623
F-statistic	0.070288	Durbin-Watson stat	1.035361
Prob(F-statistic)	0.975319		

