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MORALITY BEFORE KNOWLEDGE

The role of big data in addressing the tobacco fiscal paradox in Indonesia: A literature review and descriptive analysis of policy oversight effectiveness

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ABSTRACT

Background: The structure of the goods and services market in Indonesia cannot be separated from tobacco or cigarette commodities. In everyday life, households as consumers often include cigarettes—tobacco's primary output—among their essential utilities, alongside food, clothing, and shelter, all of which are closely linked to household income. This situation gives rise to a paradox, particularly in light of the fiscal allocation to sectors other than health. Therefore, this study aims to analyze the literature and provide a descriptive review of the use of big data and the structure of the tobacco commodity market in order to identify effective fiscal policies for tobacco products. **Methods**: This study utilizes secondary data, including: (i) literature articles and legal or regulatory documents; (ii) data from Statistics Indonesia/*Badan Pusat Statistik* (BPS); (iii) the national and regional government budgets; (iv) World Development Indicators; and (v) our world in data by Oxford University. The research design focuses on Indonesia as the primary unit of analysis at the national level, which is then compared with other countries to generate a research synthesis through a literature review. This is further supported by descriptive analysis that serves as the basis for policy recommendations. **Findings:** The study reveals three main findings. First, there is a critical need to improve education, financial literacy, and digital literacy among the population. Second, strengthening public trust in government institutions is essential in order to increase state revenue. Lastly, the government's utilization of digital technologies and big data plays a significant role in enhancing governance and policy effectiveness. **Conclusion:** The core issue identified in this study can be summarized as the need to address cross-budgeting challenges through innovations such as the use of facial recognition technology powered by big data to identify smokers. **Novelty/Originality of this article:** This study employs both theoretical and empirical literature, supported by descriptive analysis.

KEYWORDS: big data; fiscal policy; tobbaco control.

1. Introduction

The distribution of tobacco, as a natural resource commodity, has expanded widely across various countries. In biological taxonomy, tobacco belongs to the genus *Nicotiana* and the species *Nicotiana tabacum*. This classification is based on both morphological and physiological characteristics. Morphologically, the criteria include the structure of the leaves, stems, and roots; while physiologically, the classification is based on internal functions of living organisms, such as, (i) the composition of chemical compounds, (ii) hormonal activity, and (iii) metabolic processes. Tobacco is classified under the genus Nicotiana due to the intersection of its morphological and physiological traits, including a

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taproot system that serves as the initial site for nicotine biosynthesis, which is then transported to the leaves (Akehurst, 1981).

In terms of biosynthesis, nicotine has a chemical structure defined by IUPAC that includes an alkyl group (methyl), nitrogen within the pyrrolidine ring, and another nitrogen within the pyridine ring. Each of these rings undergoes distinct processes, both of which are essential to the formation of the nicotine compound (Bhambhani et al., 2021). The presence of nicotine, when consumed by living beings, affects neurological and psychological performance. Experimental studies testing nicotine effects on mammals have shown a neural system response that leads to drug-seeking behavior, a phenomenon explained by the activity of Nicotinic Acetylcholine Receptors (nAChRs) (Dani & Heinemann, 1996).

Drawing from the disciplines of biology and chemistry, we can understand how tobacco, initially introduced as cigarettes, became a global commodity. Tobacco was first documented during the time of Christopher Columbus in the Americas (Akehurst, 1981), and its distribution eventually spread across Europe and Asia. This widespread distribution is largely due to the addictive compounds in cigarettes, which create a perceived utility and preference in consumption (West, 2017), a process that is technically explained through the functioning of nicotinic acetylcholine receptors.

In biological studies, rats have been used as analogs to humans in cigarette consumption experiments. These studies found that cigarette intake increased dopamine levels, a neurotransmitter associated with feelings of pleasure (Dani & Heinemann, 1996; Goldberg & Henningfield, 1988). The addictive nature of smoking subsequently leads to serious health problems (West, 2017), such as Chronic Obstructive Pulmonary Disease (COPD) (Das, 2003), lung cancer, and throat cancer (Perez-Warnisher et al., 2019).

While utility theory often treats cigarettes as a commodity with positive market value—particularly in many developing countries (Li & Guindon, 2013)—some studies have shown that cigarettes hold negative value in other regions, such as the People's Republic of China (Yang, 2022) and OECD countries (Cantarero-Prieto et al., 2023). Literature also indicates that inequality within the social structure influences cigarette consumption, with the highest intensity of smoking found among lower- and middle-income groups (Hiscock et al., 2012). This connects to microeconomic theory, which posits that budget constraints shape utility decisions. In mathematical terms, or in Carl Menger's utility model U = f(X1, X2, ...), utility is modeled as a combination of multiple inputs (Walter & Snyder, 2010). One rational rule within this model is transitivity, meaning that if the utility of good A is greater than that of good B, then good A will be prioritized (Pindyck & Rubinfeld, 2018).

Basic utility measurement can be aligned with the psychological hierarchy of needs, which is divided into three levels, (i) physiological needs, including food, clothing, and shelter; (ii) safety and social needs, which involve transportation, information, and communication; and (iii) esteem and self-actualization needs, which include luxury goods (Maslow, 1943). As a commodity, cigarettes are priced differently across countries depending on the availability and quantity of tobacco, its primary ingredient. Tobacco has varying levels of resilience across geographic regions. In drought simulations, studies comparing tobacco grown in the United States and China found that Chinese tobacco showed greater drought resistance (Shi et al., 2025). This longer durability contributes to a relatively stable supply, which keeps prices steady and accessible to consumers.

However, in lower-income social groups where basic needs (food, clothing, shelter) take priority, two common behavioral assumptions emerge, (i) individuals may allocate a higher proportion of their income to cigarettes than to basic necessities (Block & Webb, 2009); and (ii) individuals may opt for untaxed cigarettes, which are cheaper (Ahrens, 2009). These behaviors violate the principle of transitivity in rational utility theory and are instead categorized under the concept of rational addiction (Becker & Murphy, 1988). Therefore, the aim of this study is to propose strategies for reducing the utility derived from nicotine addiction through cigarettes.

Addiction, public health, and market equilibrium are key factors that need to be regulated by the government. Such regulation can be implemented through fiscal policies that govern the availability of public goods to ensure the equitable distribution of welfare.

Fiscal policy encompasses the concepts of state revenue and expenditure, which are closely related to the three primary functions of government; (i) distribution, (ii) allocation, and (iii) stabilization (Mangkusoebroto, 1995). In the context of tobacco commodities, the interaction between the government and society is mediated through markets—both the goods and services market and the labor market. In the goods and services market, the concept of state revenue is applied through policy instruments such as taxes and subsidies, which can be modeled accordingly.

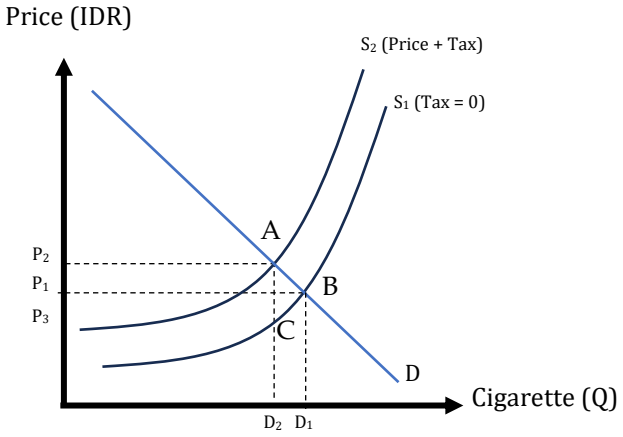


Fig. 1. Model of the tax and subsidy curve in the goods and services market (Stiglitz & Rosengard, 2015)

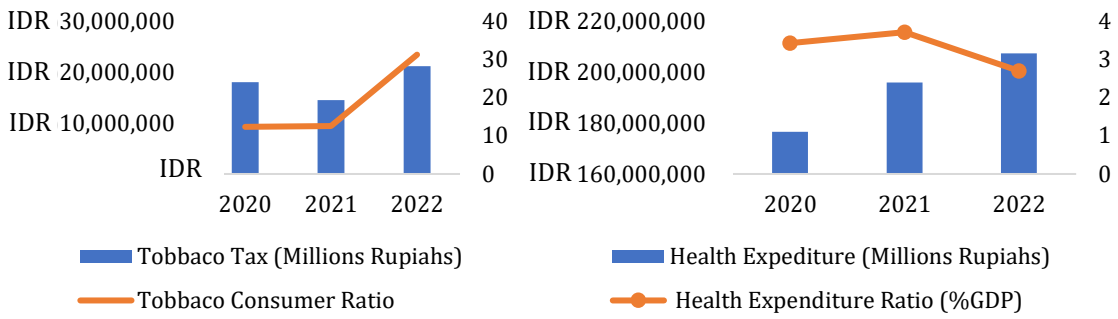
In Fig. 1, the real-world condition of the goods and services market is represented by point A, which reflects the outcome of intervention through tax instruments, excise duties, or similar measures that influence prices. This condition is linked to producer behavior in the production cost function $C=(1+t)w\cdot l+v\cdot k$ (Walter & Snyder, 2010). Meanwhile, point B represents a hypothetical scenario without tax or excise instruments, which may involve two possibilities; (i) a subsidy, in which the government provides financial support to cigarette producers to reduce production costs; or (ii) the absence of tax or excise payments due to high production costs.

In such cases, fiscal policy instruments may result in a burden known as Dead Weight Loss (DWL), illustrated by the triangle ABC, which indicates inefficiency for all parties (Pareto inefficiency) (Mangkusoebroto, 1995; Stiglitz & Rosengard, 2015). If there is no subsidy for tobacco commodities and tax evasion occurs, government tax revenue will decline, subsequently affecting public expenditure.

Both theoretical and empirical literature indicate that government expenditure contributes to economic growth, whether in the Keynesian model or the Musgrave model (Musgrave, 1959). Nonetheless, both revenue and expenditure play a crucial role in representing the purchasing power or consumption level of society. This is examined in studies on the relationship between tax revenue and Gross Domestic Product (GDP), commonly referred to as the tax ratio. Developing countries tend to have a tax ratio below 20%, while developed countries typically exceed 20% (Abd Hakim et al., 2022). In developing countries, tax revenue is predominantly sourced from value-added tax (VAT) (Tikhonova et al., 2019), which contrasts sharply with the high cigarette consumption in these countries. This suggests that a significant portion of tobacco consumption occurs without the imposition of taxes or excise duties. Consequently, the objective of this study is to propose strategies for cigarette consumption management that can be implemented to enhance government revenue.

In this context, fiscal policy in developing countries presents a paradox, whereby government revenue from tobacco is relatively low while public expenditure to address the negative impacts of smoking remains substantial. This issue is also linked to the revenue systems in developing countries, which often lack simplification and impose administrative

burdens (Gnangnon & Brun, 2019). Therefore, one of the aims of this study is to identify strategies for simplifying revenue collection, particularly for tobacco products. The research focuses on developing countries, with Indonesia as one of the case studies. Observations of the COVID-19 period reveal that tax revenue from tobacco was proportionally smaller compared to the ratio of cigarette consumers within the Indonesian population, as illustrated in Fig. 2.



(a) (b)

Fig. 2. a) Cigarette tax revenue, b) budget allocation for the health sector (Statistics Indonesia, 2025; World Bank, 2025)

In Fig. 2, it can be observed that Indonesia faces a fiscal paradox in relation to tobacco commodities and the health sector. While health expenditure has increased, its ratio to GDP has declined. This paradox occurs alongside a rise in cigarette consumption amid unstable cigarette tax revenue during and after the pandemic. At the same time, there has been a rapid digital technology transition. Accordingly, this study formulates the following research questions; (i) what strategies can be implemented to optimize the utility derived from nicotine addiction in cigarettes?, (ii) what cigarette consumption strategies can be applied to increase government revenue?, (iii) how can health sector spending be made more effective in addressing the tobacco fiscal paradox in the digital technology era? The underlying hypothesis is that greater stringency, transparency, and accountability can enhance revenue collection, which in turn can contribute to future fiscal policy recommendations, provided that appropriate technological adaptations are incorporated to address the issue. The remainder of this paper is organized as follows, presents the research methodology; discusses the results and analysis; and provides the conclusion.

2. Methods

To address the research questions, this study adopts a mixed-methods approach, combining qualitative and quantitative methods. The qualitative method serves as the primary approach to answer the research questions, while the quantitative method functions as a supporting approach. The qualitative method is implemented through a literature review consisting of, (i) journal articles as empirical studies indexed in Scopus and SINTA; and (ii) international regulations or regulations from the country under study. The literature review is organized into three variables or keywords, as shown in Table 1, with no restriction on the time span of the sources.

The quantitative method employs descriptive analysis using secondary data from: (i) Our World in Data, Oxford University; (ii) the National and Regional Government Budgets/*Anggaran Pendapatan dan Belanja Negara dan Daerah* (APBN/APBD); and (iii) the World Development Indicators (WDI) and Statistics Indonesia (BPS). These two types of data serve different purposes—specifically, to identify and support the variables used as keywords in the literature review, as presented in Table 1.

Table 1. Operational variables of the literature review

Variable/Keyword	Qualitative Method	Quantitative Method	
	Estimated Number of Article Reviews	Database	Time Range
Cigaratte Consumer Behaviour	15 articles in each discussion point	Our World in Data Oxford University	1980-2023 (Partial Time Range for each discussion point)
Tax revenue and expenditure		APBN/APBD	
Fiscal, Cigaratte and Growth Economy		BPS & WDI	
Big Data and ICT Policy		-	

The operational use of these variables is based on the research background and problems, along with several empirical studies. (I) cigarette consumer behavior—this variable is used to examine the background of each individual, drawn from various relevant literature, in choosing to smoke, such as stress. (II) tax revenue and expenditure—this variable is used to observe how revenue and expenditure structures are allocated across sectors in the country under study. (III) tax, cigarette, and economic growth—this variable is used to compare the research object country with other countries in terms of how fiscal policy and cigarettes contribute to growth. (IV) big data and ICT policy—this variable is used to examine how different countries adapt their policies in the technological era. For a clearer explanation, refer to the research design or model in (Fig. 3).

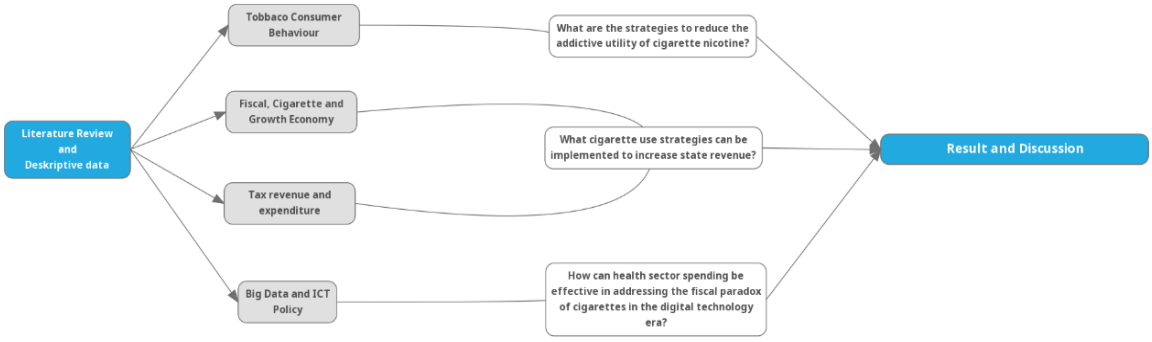


Fig. 3 Research design of operational variables

3. Results and Discussion

3.1 Strategies to optimize the addictive utility of nicotine cigarettes

In implementing a strategy to optimize utility, two aspects can be considered; (I) the psychological–economic aspect, which examines the optimization model using the Lagrange equation for consumers (Walter & Snyder, 2010), namely,

$$L = U(X, Y) + \lambda(I - PxX - PyY) \quad \text{(Eq. 1)}$$

Hands (2010) explains the historical background of how optimization or equilibrium models originated from Walras' tâtonnement, which describes how the concept of equilibrium between supply and demand can be understood through the initial capital or endowment one possesses. Simply put, it reflects Adam Smith's laissez-faire philosophy, in which price-setting agents become benchmarks for the final price of an output. However, in reality, this is seen as both static and dynamic—an idea criticized in some empirical works, such as bounded rationality, which is an economic experiment examining how producers respond to the price of an output and to income within labor contracts. This study seeks to explore how changes in both conditions can occur. The findings indicate that some

producers are suspected of seeking profit based on individuals' psychological states in the market, due to limited information that affects cognition (Kahneman et al., 1986). Walras' tâtonnement has since been developed using the Lagrange equation with rationality in consumer preferences—or rationality in utility—based on three main principles. The first is transitivity, which refers to individuals' ability to form a hierarchy of utilities, where a preference for an option lower in that hierarchy would be deemed irrational. The second is completeness, which requires individuals to choose between the utility of one good, the utility of another good, or both. The third is continuity, which asserts that preferences are not discrete values but continuous, implying that there is a probability or proportion of desired goods or services based on the established preference hierarchy (Varian, 2010; Walter & Snyder, 2010).

Violations of these three rationality principles can be linked to bounded rationality, caused by imperfect information or suboptimal cognitive ability. In health science, research has been conducted on cognitive ability and smoking. In Sweden, an experiment was conducted on two groups: a control group of non-smokers and a treatment group of smokers with varying intensities, using education as a control variable. Participants were also classified by age to examine patterns of significant cognitive decline between smokers and non-smokers. The results showed that active smokers tend to perform worse on cognitively demanding tasks, such as block design and free recall, and that adolescents experience a much sharper decline in cognitive ability compared to non-smokers (Hill et al., 2003). These findings are reinforced by similar results from research in the United Kingdom, which found other evidence related to reduced brain gray matter volume—particularly in the thalamus—associated with lower cognitive function (Linli et al., 2023). Other studies also indicate that cognitive decline in adolescent and adult active smokers is significantly different from that of non-smokers, while the difference in adults and the elderly is not significant (Corley et al., 2012; Goriounova & Mansvelder, 2012). Considering this, formal education can be indicated as one factor influencing smoking status, as seen in the control variables of Hill et al. (2003), which also affect decision-making (Daly & Egan, 2017). This suggests the potential for bounded rationality, in which individuals prioritize continuous smoking over fulfilling basic needs. In addition to education, other aspects should be considered in optimizing addiction utility, which can be seen in Appendix 1, related to cigarette consumption in various countries.

In Appendix 1 it appears that some developed countries have poor conditions when we examine the maximum values. For example, code [09] Australia and code [10] Austria once reached 30% of their population consuming cigarettes. Code [86] Japan almost reached 40% at its maximum value, along with other developed countries mentioned. Meanwhile, developing and transition countries have lower maximum values—for instance, code [103] Malaysia, code [80] Iraq, and [81] Iran. Even in parts of Central America, such as code [85] Jamaica, [73] Guyana, and [40] Costa Rica—regions known as early tobacco distribution hubs—the annual average cigarette consumption is relatively small.

Appendix 1 measures this by calculating the average of yearly values for each country. When linked to microeconomic theory, this aligns with Engel's Law, which states that as income increases, the proportion of spending on basic needs such as food decreases. Thus, in developed countries, cigarettes can take a larger share of consumption, while in developing countries, the focus remains on fulfilling food needs (Chai & Moneta, 2010). In developed European nations, cigarette consumption is closely tied to socio-cultural aspects, which will be discussed later in section (II) socio-cultural aspects. In the case study country, Indonesia—classified as developing—the minimum and maximum values are not significantly different from other countries. Several empirical studies on consumer preference rationality in the Lagrange equation show links to cigarette addiction. For instance, dynamic modeling research has examined the relationship between intertemporal consumption of non-addictive goods (such as crackers and butter) and addictive goods (cigarettes) under tobacco control policies through fiscal measures (taxes and subsidies).

The findings can be summarized into three main points. First, cigarette consumption, particularly among individuals with addiction, is higher than the consumption of crackers

and butter. Second, cigarette consumers tend to have lower savings for the future compared to those who consume crackers or butter. Third, the price elasticity of cigarettes is high—when fiscal policy changes, such as tax increases, are implemented, consumers may shift from premium to regular cigarettes, and if both are taxed, they tend to substitute with per-stick cigarette purchases. Limited income does not deter smoking behavior, and substitution toward crackers or butter remains minimal (Gordon & Sun, 2015). Therefore, an important area for improvement lies in financial management to prevent excessive spending on cigarettes. Furthermore, qualitative case studies on addictive consumption—such as alcohol, cannabis, and cigarettes—show that tax-induced price changes do not necessarily reduce cigarette consumption or cause substitution toward other needs. Individuals often ignore the long-term financial and health consequences (Andersson et al., 2006). This is echoed in valuation studies using discounting and present value, which reveal that smokers have benefits that are not distributed for the long term (Ida, 2014; Harrison et al., 2018).

Interestingly, developed countries have had lower minimum values compared to the case study country, Indonesia [79]. Empirical evidence suggests that factors such as stress, boredom, and anxiety can cause diminishing marginal utility for basic needs when constraints are unmet (Garey et al., 2023; Gregor et al., 2008; Guillot et al., 2015; Sarafim-Silva et al., 2019). When this is viewed alongside the data in Appendix 1, several global events align with spikes in stress and smoking, the 2008 Global Financial Crisis, the 1990 Influenza Pandemic, and Middle East wars that spiked oil prices and caused economic shocks. Similar patterns have been found in more recent events, with studies showing that social restriction policies during the pandemic increased stress and smoking in Mexico (Loud et al., 2021), Finland (Ruokolainen et al., 2024), the Netherlands (Bommelé et al., 2020), Brazil (Schäfer et al., 2022), the United States (Nagawa, 2019), and the United Kingdom (Chen, 2020). With its large population, Indonesia holds significant potential for stress-related overconsumption of cigarettes, which can result in excessive addictive utility and place a heavy burden on the health sector. Therefore, both in theory and in practice, Indonesia can adopt several strategies to optimize rational addiction. First, improving cognitive abilities among low-income groups through programs such as Smart Indonesia Card/*Kartu Indonesia Pintar* (KIP), Smart Indonesia Program/*Program Indonesia Pintar* (PIP), and Jakarta Superior Student Card/*Kartu Jakarta Mahasiswa Unggul* (KJMU), accompanied by policy measures that mandate evaluation and transparency audits of cigarette consumption to better regulate addictive utility. Second, promoting financial and digital literacy, with a focus on understanding how intertemporal choices differ between smokers and non-smokers, providing knowledge on financial management to influence both present and future spending decisions, and ensuring equal access to accurate health information. Third, allocating and distributing public goods that foster peace and happiness—such as public parks, town squares, and mobile psychological services—while avoiding fragmentation in the social and economic structure.

The socio-cultural aspect is closely related to the economic aspect in the discussion of cigarettes. When linked to the previous optimization model, which included functions related to utility and constraints, the socio-cultural dimension connects to income or transaction costs. Indonesia, as the research object, has a Gross Domestic Product (GDP) per capita of USD 4,876.31 (World Bank, 2025), or approximately 70 million rupiah per year. Empirical evidence shows that when Indonesia's GDP per capita is modeled at the regional–provincial level, disparities have existed between Java and non-Java islands since 1870–1930 (Bosma & van Leeuwen, 2023) and continued between 2000–2010 (Wajdi et al., 2017), indicating lower welfare in non-Java regions. This potentially leads to higher cigarette consumption, especially as prices in Indonesia remain relatively low given its natural resource advantage, including tobacco (Setyonaluri et al., 2008). Culturally and historically, the distribution of tobacco has increased consumption levels in certain areas, as seen in countries mentioned in strategies to optimize the addictive utility of nicotine cigarettes. Empirical evidence also points to customary laws rooted in the culture of tobacco-rich communities, such as Native American tribes in the United States (Beauvais et al., 2007), Mongolian tribes (Sharaeva, 2019), and Samoan tribes (McCool et al., 2014).

However, such cultural and social norms often conflict with health regulations, especially when cigarette addiction and low cognitive ability lead individuals to resist these rules. For example, research in Indonesia has examined whether compliance with Smoke-Free Area/*Kawasan Tanpa Rokok* (KTR/SFA) regulations reduces smoking prevalence and associated diseases such as diabetes, heart problems, and lung conditions by limiting cigarette access. The results surprisingly showed a significant increase in those diseases despite restricted access (Crosby et al., 2019; Martini et al., 2022).

The relationship between regulation and society is inherently tied to institutions, where rules should be built through communication that integrates local customs and culture. This approach can enhance social capital, which is strongly linked to cognitive development, ultimately reducing cigarette transactions. This concept is reflected in a study of an indigenous tribe in Maluku, which practiced rotational fishing management among family clans. In this system, each clan would take turns fishing and feeding other clans, fostering strong social capital and cognitive awareness. Beyond fishing, the community understood the need to let fish stocks replenish, respecting specific times when fishing was prohibited—a concept aligned with sustainability principles (Zerner, 1994).

3.2 Strategies to address cigarette consumption issues for increasing state revenue

The discussion focused on how to optimize the addictive utility of cigarettes. Although some empirical findings in that section indicate that taxes and other fiscal instruments may not fully address the issue, this study attempts to build literature on the potential revenue and distribution allocation for strategies to optimize the addictive utility of nicotine cigarettes so that it can be adapted to Indonesia's state finances. As noted in section strategies to optimize the addictive utility of nicotine cigarettes, there are two aspects with several proposed solutions: education, finance, digitalization, and the allocation of public goods such as entertainment, as well as building public trust in the government's adaptation of intended regulations. The elasticity of cigarette substitution has been explained, and this creates the potential for the circulation of illegal cigarettes. Illegal cigarettes themselves can form their own market system. Rational addiction exhibits high elasticity toward different types of cigarettes, and when paired with companies that do not pay taxes or customs duties, this is referred to as the shadow economy (Poufinas et al., 2021). The shadow economy trend is prevalent in developing countries, with many cross-country case studies available. OECD countries have the smallest shadow economy growth, at 17%, while non-OECD high-income countries report 24%, upper-middle-income countries 37%, and lower-middle-income countries 38% during the period 1984–2006 (Alm & Embaye, 2013). The shadow economy also harms economic growth. Across 110 countries in 1990–2000, it was identified that in developing and transition countries, shadow economic activities reduced measured economic growth by 0.7–1% (Abou Ltaif et al., 2024; Schneider, 2005). In another study comparing two developing countries, Russia—transitioning from the Soviet Union—was examined during 2005–2010. The results found that shadow economy growth in both countries ranged between 25%–32% (Manita & Khoirunurrofik, 2021). From the cigarettes within the shadow economy, we can observe the percentage of state revenue across various regional areas between countries, as shown in Table 2.

Table 2. Descriptive statistics of regional panel data across countries in the world, 2018–2023

Region	Obs	Mean	Std. Dev	Min	Max
MENA (Middle East & North Africa)	54	12.84	9.00	0.05	25.42
East Asia & Pasific	120	17.7	5.61	7.51	30.2
OECD & Europe Central Asia	12	17.7	2.1	15.4	21.4
Europe Central Asia (Excluded High Income)	6	16.27	0.47	15.5	16.97
Total	192				

(World Bank, 2025)

The limitation in Table 2 lies in the classification of countries based on regions, which appears uneven in the panel observations. However, it can be identified that the OECD economic organization has a higher contribution of government revenue to Gross Domestic Product compared to other groups, followed by the Europe and Central Asia region—even when classified as excluding high-income countries. Both of these regions have a wide distribution, which means a small level of inequality. Assuming n=30, this could indicate that these regions have relatively even conditions. In contrast, the Middle East and North Africa (MENA) region shows a disparity between the minimum and maximum values, with the highest value of 25.42% coming from Israel. Similarly, East Asia and the Pacific also demonstrate disparities, as evidenced by the differences in observations compared to OECD and European countries, which have fewer but more evenly distributed values. Therefore, the shadow economy potential in regions such as MENA and East Asia & Pacific is higher. What can cause variations in government revenue within fiscal policy and its instruments can be explained from both theoretical and empirical/practical perspectives.

Theoretically, there is research discussing the relationship between utility, income constraints, and regulatory strictness. If utility is high, as in the rational addiction model for cigarettes—assuming cigarette prices have already been taxed, which is considered a tax incidence (Mangkusubroto, 1995)—then cigarette consumers are directly affected by price changes. Empirical findings show that in several developing countries, income inequality and significant legal loopholes lead individuals to commit criminal acts such as purchasing untaxed or smuggled cigarettes. This concept was first introduced in Becker's (1968) study on crime and punishment. From the producer's perspective, empirical studies have found that tax avoidance is often driven by lengthy and complicated bureaucratic processes. One study, using a Randomized Control Trial approach, simulated the impact of three tax collection methods in Indonesia, namely simplification through digital technology, deterrence through the dissemination of legal information, and the implementation of bureaucratic procedures through the institutions responsible for taxation. The findings show that simplification is the most effective method for improving tax compliance compared to manual bureaucratic procedures (Yogama et al., 2024). This is also supported by simulations in Ukraine, where manual bureaucratic systems were replaced with digital systems (Paientko & Proskura, 2016). Other countries have also implemented big data–based digital systems as a primary source of information, such as Caribbean nations (da Silva et al., 2025) and European Union countries (Zwick, 2015), to monitor social and economic conditions and ensure optimal utility under the law. Another reason producers avoid paying taxes relates to social capital and institutional quality.

Theoretically and empirically, in a neoclassical market, the government's role is to allocate, distribute, and stabilize for Pareto optimality through fiscal policy. However, corruption, collusion, and nepotism in state revenue reduce public trust in the government as a regulatory body, thereby impacting tax payments and potentially economic growth (Acemoglu & Robinson, 2008; Knack & Keefer, 1995). Empirically, issues of institutional quality and social capital in fiscal policy are common in developing countries (Waqar et al., 2022), driven in part by infrastructure inequality and slow technology transfer from developed countries (Sachs, 2001). Without initial infrastructure and technology, the recommendations from strategies to optimize the addictive utility of nicotine cigarettes cannot be implemented. Beyond social capital and digital simplification, fiscal revenue policies such as taxation must take into account whether the primary objective is efficiency or equity. According to Mangkusubroto (1995), there are four main methods of taxation; progressive taxation, in which higher income is taxed at a higher percentage; regressive taxation, where lower income is taxed at a higher percentage; proportional taxation, in which all income levels are taxed at the same percentage; and lump sum tax, which applies a fixed amount of tax to all individuals regardless of their income level. Empirically, progressive taxes are considered equitable in terms of income distribution, but if rates are too high, they still lead to high levels of tax evasion and moral costs among high-income groups (Goerke, 2003).

Table 3. Changes in state revenue of the national budget (APBN) for the years 2018–2024.

Source of Income – Finance	CAGR	
	Growth	Percent
I. Domestic Revenue	0.054843	5.48431
1. Tax Revenue	0.061726	6.17263
a. Domestic Tax	0.061379	6.13792
(1) Income Tax	0.061617	6.16168
i. Oil and gas	-	-
ii. Non-Oil and Gas	-	-
(2) Value added tax and sales tax on luxury goods	0.060657	6.06572
(3) Land and building tax	0.049017	4.90174
(4) Land and building acquisition tax	0	0
(5) Excise	0.063819	6.38187
(6) Other Taxes	0.068609	6.86086
b. International Trade Tax	0.072522	7.25223
(1) Import Duty	0.056241	5.62411
(2) Export Tax	0.145686	14.5686
2. Non-Tax Revenue	0.026632	2.66324
a. Receipt of Natural Resources	0.020158	2.01583
b. Income from Separated State Assets	0.09645	9.64499
c. Other Non-Tax Revenue	-0.01565	-1.56464
d. Public Service Agency Income	0.060934	6.09341
II. Grants	-0.40101	-40.1012
Amount	0.053655	5.36553

(DJPb, 2025)

Regressive taxes can also result in high tax evasion but with lower moral costs among high-income earners (Lee, 2016). For Indonesia, the strategies to increase state revenue in this study include updating fiscal policy regulations with a simplified, digital-based system that leverages big data to detect tax evasion by both producers and consumers engaged in the shadow economy; preventing corruption, collusion, and nepotism by reforming tax collection systems through the use of self-assessment and third-party intermediaries such as companies, as well as enhancing transparency and reporting of government financial data to build public trust; and implementing a fair tax system that accommodates both high-income and lower-to-middle-income groups. As the research object, Indonesia has a decentralized fiscal policy structure encompassing the national budget (APBN) and regional budgets (APBD), as stipulated in Law Number 23 of 2014. Table 3 presents the growth of tax revenues by type from 2018 to 2024.

Income from income tax as well as value-added tax is still significantly lower compared to export tax and import duties. Therefore, this should serve as an evaluation point for the government regarding domestic revenue so that the fiscal paradox in tobacco and health can be addressed.

3.3 Strategies for effective health sector expenditure in addressing the tobacco fiscal paradox in the digital technology era

To support big data technology innovation in transforming cigarette consumption patterns and eliminating the fiscal paradox in addressing tobacco-related issues, it is necessary to integrate relevant regulations with policy development based on existing phenomena and an analysis of national and regional budget allocations across various government sectors. Tobacco control regulations aim to tighten restrictions in public areas, as stipulated in Government Regulation (PP) No. 28 of 2024. These measures include prohibiting the sale of tobacco products and electronic cigarettes to individuals under the age of 21 and pregnant women; banning cigarette sales within a 200-meter radius of educational institutions and children's playgrounds; restricting cigarette advertisements on social media and limiting television ads to the hours between 10:00 p.m. and 5:00 a.m. local time; and implementing plain, brand-free packaging for tobacco products to reduce their

visual appeal. In addition, Minister of Health Regulation/*Peraturan Menteri Kesehatan* (*Permenkes*) No. 40 of 2013 provides technical guidelines for local governments to implement smoke-free zones in public areas. However, the problem cannot be resolved solely with written regulations. A case study in Jakarta revealed that 70% of people still smoked in public spaces (Kompas, 2015). From a microeconomic perspective, this reflects inefficiency caused by moral hazard resulting from the rational addiction associated with smoking. Research on tax compliance in Indonesia indicates that decision-making or cognition is often emotionally driven, and Indonesians respond more effectively to simplification or nudging (Yogama et al., 2024). Deterrence measures still appear to be significant, linking to the concept of bounded rationality (Kahneman et al., 1986). While bounded rationality resembles rational addiction, in this innovation the emphasis is on combining nudging with deterrence—through big data technology that integrates comprehensive information about Indonesian residents, cigarette types, and thermal scans—to reduce moral hazard via real-time monitoring. In regulating cigarette consumption, it is also essential to understand Indonesia's information technology laws to prevent data misuse. Law No. 27 of 2022 (Articles 20 and 22) governs data processing for public services, law enforcement, and public order. Law No. 24 of 2013 on Population Administration regulates the protection and use of population data, including NIK and biometric data (facial photos, fingerprints), which can only be used for public services and law enforcement with proper authorization. Government Regulation No. 71 of 2019 on the Implementation of Electronic Systems and Transactions (Articles 14–20) emphasizes principles of personal data security, data owner consent, and the right to access or amend personal data. Some rules already permit the use of citizens' personal data for law enforcement purposes. This innovation seeks to develop big data combined with cameras or CCTV equipped with facial recognition for real-time monitoring without public complaints. However, the challenge lies in the massive use of AI—currently without specific regulations to support such innovation—which must be addressed to build public trust in the Indonesian government.

In addition to existing regulations, it is necessary to understand the budget conditions for government expenditures in sectors related to this innovation. According to DJPK and *APBNkita*, at the regional level (APBD), budget classifications in the health, public order/security, housing and public facilities, and social protection sectors serve as a reference for tightening cigarette consumption. In 2022, mandatory spending in the health sector amounted to IDR 207,273,101,921,411, with the largest proportion allocated to goods/services. This proportion is optimal for innovation as it can support public outreach and education on the dangers of smoking. The public order and security sector had an allocation of IDR 13,802,798,534,907.50, social protection IDR 12,687,429,860,035, and housing and public facilities IDR 13,757,383,572,293.80. The author assumes that technological innovation can also be allocated within the three sectors other than health. For example, technology could serve a social protection function by addressing smoking-related externalities affecting pregnant women, or contribute to public order and security by integrating big data systems to record violations of smoking regulations—thereby reducing information asymmetry among citizens unfamiliar with the law. For housing and public facilities, the function would be to distribute big data and facial recognition technologies to neighborhood, sub-district, and city/district levels, as well as public facilities such as hospitals, parks, and even traffic lights to reduce smoking in public spaces. Big data technology itself has a strong conceptual foundation for implementing existing smoking regulations, particularly when integrated with monitoring tools like CCTV cameras. In line with big data policy concepts, big data is more effective for generating new hypotheses about urban problems than for directly proposing policy solutions. While real-time data can reveal patterns, understanding cause-and-effect still requires theories and contextual data. Theory remains crucial in the big data era, as interpreting rapid data patterns demands conceptual frameworks to explain the complex social dynamics behind them (Kandt & Batty, 2021). From a fiscal policy analysis perspective, this approach can ensure more precise budget allocations, avoiding inefficiency in high-proportion spending

sectors, while also helping research by improving the accuracy of error term estimations. Big data and facial recognition CCTV innovations are outputs involving multiple sectors, such as information technology and public administration, potentially producing a multiplier effect. Therefore, beyond budget proportion considerations, cross-sectoral budgeting is needed. This approach involves planning and allocating budgets across several government spending sectors to address a single strategic issue, acknowledging that many public problems—such as health, public order, security, technology, and the environment—are multidimensional and cannot be solved by a single sector's budget alone (Christensen & Lægreid, 2007; Pollitt & Bouckaert, 2017). This concept has already been implemented in Indonesia, most notably in the post-pandemic era through the Electronic Traffic Law Enforcement (ETLE) program, which integrates funding from the police, regional transportation agencies, and communication and informatics agencies. A similar model could be applied to big data innovations in facial recognition cameras for smoking control—detecting public smoking, identifying cigarette types (with AI visualization to determine legality), and providing transparency and regulatory information, as well as calculating fines for violators. However, big data innovation also has weaknesses in multiple dimensions. In fiscal policy, cross-budgeting could create opportunities for political turbulence due to high incentives in its implementation. Moreover, the lack of regulations, such as those governing AI use, raises the risk of misuse by certain individuals to manipulate existing regulations. Public awareness is also a challenge, as seen in various news cases involving theft of public facilities (ANTARA, 2025).

4. Conclusions

The conclusion drawn from the discussion of the three strategic pillars—namely optimizing addiction utility through education and literacy, strengthening cigarette tax revenue through credible institutions, and innovating healthcare sector spending mechanisms to address the fiscal paradox—indicates that an integrated and contextual approach is key to policy success. First, educational interventions that combine behavioral, financial, and digital literacy are designed not merely to convey information, but to build individuals' critical awareness of the long-term impact of addiction. By incorporating modules on managing consumption temptations and simulating simple economic decisions, program participants are expected to internalize the implicit costs of addictive habits. This approach is complemented by formative evaluation—periodic assessments of behavior and attitudes—so that the material can be continuously adapted to audience needs. As a result, reductions in addiction intensity are not only temporary but sustainable, as attitude changes are grounded in deep understanding. Second, tobacco excise policy, formulated as a dual instrument of both fiscal and public health goals, requires strong institutional legitimacy.

Transparency in tariff-setting processes, accountability in fund management, and public participation in oversight mechanisms are prerequisites for the public to perceive the policy not merely as harmful, but as creating social benefits. The implementation of real-time dashboards and open data provides broad access to information, allowing stakeholders to assess the effectiveness of fund allocation. Collaboration between tax offices, health departments, academics, and NGOs strengthens the support base while ensuring that excise funds are directed toward prevention, rehabilitation, and behavioral change campaigns. Third, the challenge of the fiscal paradox in the health sector—where financing needs continue to grow while fiscal space remains limited—can be addressed through cross-budgeting schemes based on cost–benefit analysis. By reallocating a portion of funding from sectors with lower marginal efficiency, such as energy subsidies or high-cost infrastructure projects, health sector resources become more adequate. Furthermore, the use of big data analytics helps map disease prevalence, demographic trends, and service utilization patterns, enabling precise budget allocation.

Facial recognition technology, provided it is accompanied by strict privacy protocols and data protection regulations, supports beneficiary verification, minimizes leakages, and

increases the accuracy of targeting health assistance programs. Fourth, the synergy of these three pillars creates a holistic policy ecosystem. Educational programs reduce the emergence of new health burdens, cigarette tax revenues provide earmarked funds for health interventions, and innovative spending mechanisms ensure efficient budget utilization. Cross-sector coordination between central and local governments, academic institutions, the private sector, and civil society becomes the foundation of implementation. Data-driven governance ensures that every policy step can be measured for impact and improved in line with evolving conditions on the ground. Overall, the combination of preventive, fiscal, and technological instruments not only builds a more resilient health system but also supports the achievement of sustainable development goals: reducing addiction prevalence, improving quality of life, and ensuring equitable healthcare access. Practical recommendations include; (1) developing an adaptive addiction curriculum, (2) strengthening institutional capacity in taxation through digitalization and public accountability, and (3) implementing big data governance in healthcare budgeting. Thus, the policies designed will remain relevant, effective, and sustainable.

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Conflicts of Interest
The author declare no conflict of interest.

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Appendix 1. Descriptive statistics of cigarette consumption (all population groups) in 188 countries, 1980–2010

Country Code	Obs	Mean	Std. Dev	Min	Max	Country Code	Obs	Mean	Std. Dev	Min	Max
1	33	11.321	0.591	10.4	12	95	33	34.761	4.690	26.6	39.4
2	33	20.421	1.093	18.1	21.4	96	33	19.900	1.692	16.6	21.5
3	33	14.882	2.031	10.9	16.9	97	33	7.294	0.402	6.3	7.8
4	33	29.891	1.583	26.6	31.2	98	33	12.703	2.053	10.4	16.7
5	33	8.852	0.071	8.7	8.9	99	33	23.188	2.081	20.9	25.9
6	33	3.924	0.557	3.4	5.2	100	33	28.900	2.277	25.1	32.6
7	33	24.021	1.848	19.3	26.3	101	33	19.809	3.095	13.6	22.4
8	33	27.009	0.739	26	28.2	102	33	12.027	1.277	9.7	13.1
9	33	22.976	4.356	16.3	30.5	103	33	21.500	1.674	18.8	23.6
10	33	28.458	1.845	25.5	31.6	104	33	19.433	0.800	18.3	20.8
11	33	20.961	0.599	20.2	22.4	105	33	10.185	0.097	10.1	10.4
12	33	10.539	0.448	9.9	11.2	106	33	25.827	2.670	21.6	29
13	33	15.797	2.017	12.1	19.1	107	33	18.952	0.585	17.7	19.5
14	33	23.412	0.658	22.4	24.6	108	33	10.906	1.331	9.3	13
15	33	6.582	0.333	6	7	109	33	19.594	1.771	17	21.5
16	33	28.021	1.805	25.1	30.4	110	33	18.106	6.801	9.3	26
17	33	28.909	2.663	25	32.5	111	33	25.197	0.714	24.3	26
18	33	9.567	0.773	8.5	11.1	112	33	22.555	3.096	19	26.2
19	33	8.439	0.497	7.7	9.4	113	33	22.415	1.177	20.9	25.4
20	33	11.042	0.492	10.4	12	114	33	27.345	0.368	26.5	27.8
21	33	31.855	3.550	24.4	35.3	115	33	13.655	0.160	13.4	13.9
22	33	35.942	2.417	31.2	38.7	116	33	11.530	0.359	11	12.3
23	33	13.994	0.705	13.2	15.5	117	33	20.164	1.525	17.5	21.6
24	33	17.000	1.676	13.8	19.8	118	33	16.624	1.427	14.3	18.1
25	33	11.903	0.270	11.5	12.3	119	33	32.697	4.391	23.8	37.1
26	33	31.979	3.746	28.3	38.4	120	33	25.782	2.558	20.8	29.4
27	33	11.939	0.839	10.5	12.7	121	33	24.633	4.777	16.7	32.4
28	33	13.427	0.697	12.4	14.5	122	33	12.067	1.804	10.5	16
29	33	21.870	1.462	19.3	24	123	33	5.255	0.189	4.9	5.4
30	33	7.852	0.496	7	8.3	124	33	7.033	2.240	4	9.5
31	33	24.873	7.548	14.5	37.9	125	33	23.433	0.626	22.5	24.2
32	33	6.200	0.175	6	6.6	126	33	36.836	0.756	35	37.7
33	33	8.358	0.061	8.3	8.5	127	33	28.527	6.381	16.9	34.7
34	33	7.203	0.153	7	7.4	128	33	9.355	1.582	7.1	11.8
35	33	33.936	3.496	28.1	37.6	129	33	18.388	1.492	15.4	20.1
36	33	27.500	2.330	23.8	29.8	130	33	24.585	1.805	20.8	26.1
37	33	13.082	1.482	11	16	131	33	9.230	0.800	7.9	10.1
38	33	12.455	0.916	10.4	13.5	132	33	38.252	0.256	37.9	38.6
39	33	8.576	0.148	8.4	8.9	133	33	14.618	1.619	11.6	16.4
40	33	10.488	0.903	9.2	12.2	134	33	10.476	0.511	9.9	11.2
41	33	9.027	0.491	8.4	10.3	135	33	26.418	2.368	22.4	28.7
42	33	26.715	0.668	25.9	28	136	33	33.682	4.400	27.2	42.3
43	33	18.564	1.279	16.6	21.9	137	33	21.424	0.721	19.9	22.6
44	33	33.458	1.132	30.8	34.9	138	33	16.248	0.935	14.3	18.1
45	33	25.294	0.720	23.6	26.3	139	33	26.318	1.425	24.2	29.1
46	33	7.903	0.017	7.9	8	140	33	32.312	1.802	29.3	35
47	33	31.779	6.495	18.7	37.8	141	33	12.361	2.275	7.6	14.1
48	33	21.267	0.227	20.9	21.6	142	33	9.709	0.549	8.6	10.5
49	33	5.945	0.278	5.5	6.3	143	33	9.197	0.113	9	9.3
50	33	14.082	2.340	10.7	16.7	144	33	26.339	2.002	22.4	28.2
51	33	31.524	0.989	30	33.5	145	33	3.294	0.198	3	3.7
52	33	7.727	1.164	6	8.9	146	33	11.136	3.123	6.3	15
53	33	16.218	0.689	15.3	18.4	147	33	9.545	1.366	7	10.9
54	33	10.173	0.669	9.1	11.3	148	33	26.618	3.134	22.8	31.6
55	33	10.024	0.931	7.9	11.4	149	33	16.424	0.809	15.5	17.8
56	33	6.691	0.484	5.8	7.2	150	33	17.742	0.503	17.2	18.8
57	33	28.155	1.121	26.3	29.9	151	33	14.939	1.443	13.1	17.4
58	33	6.188	0.412	5.8	7.3	152	33	23.776	0.787	22	24.5
59	33	4.073	0.266	3.7	4.5	153	33	24.924	2.990	21.2	30.3
60	33	15.355	0.886	14.2	16.6	154	33	28.161	0.708	26.8	29
61	33	21.576	2.606	16.5	24.6	155	33	10.545	0.606	9.6	11.3
62	33	30.282	2.384	26.8	33.9	156	33	20.085	3.592	14.4	23.7
63	33	9.564	0.626	9	10.9	157	33	30.773	3.694	24	34.3

64	33	13.982	1.336	12.1	15.9	158	33	30.964	3.648	24.7	35.2
65	33	22.861	0.663	22.3	24.6	159	33	12.464	0.636	11.5	13.4
66	33	26.764	3.200	22.3	31.1	160	33	5.676	0.071	5.6	5.8
67	33	4.542	0.421	3.8	5	161	33	6.327	0.118	6.1	6.5
68	33	38.827	1.274	35.5	40.6	162	33	20.400	5.339	12.6	27.7
69	33	9.033	0.469	8	9.7	163	33	25.879	3.798	19.5	30.7
70	33	7.779	0.880	6.3	8.6	164	33	16.982	0.459	16.5	18.4
71	33	6.527	0.213	6.3	6.8	165	33	21.324	1.978	17.4	23.4
72	33	6.967	0.447	6.5	7.7	166	33	18.385	2.756	15.5	23.1
73	33	13.212	1.427	11.6	15.3	167	33	11.000	0.752	9.3	11.6
74	33	9.085	0.940	7.1	10	168	33	22.948	2.454	19.3	25.1
75	33	13.652	1.645	11.3	16	169	33	6.400	0.408	6	7.1
76	33	30.188	1.451	26.6	33.5	170	33	32.364	1.551	30.9	35.9
77	33	27.030	7.118	14.4	37	171	33	18.385	1.093	17	21.4
78	33	16.070	1.709	12.6	17.6	172	33	22.764	1.306	20.6	24.5
79	33	28.433	0.698	27.5	30.2	173	33	28.412	1.099	26.5	30.6
80	33	11.915	0.336	11.5	12.6	174	33	20.927	0.930	19.5	22.7
81	33	16.958	0.444	16.2	17.8	175	33	11.415	1.746	7.8	12.9
82	33	28.958	4.212	23.2	34.5	176	33	30.100	1.433	26.5	31.6
83	33	26.270	4.835	19.4	32.9	177	33	17.358	1.853	14.8	19.6
84	33	26.109	3.542	22.1	31.7	178	33	27.879	4.829	20.1	36.9
85	33	15.212	0.455	14.5	16	179	33	21.833	4.499	15.3	29.7
86	33	29.936	4.581	21.3	36.7	180	33	27.682	2.961	22.2	30.3
87	33	26.382	0.910	25.4	29.2	181	33	10.715	0.385	9.9	11.2
88	33	20.788	1.530	18.7	24.4	182	33	20.376	1.898	16.3	22.5
89	33	10.630	0.668	9.3	11.2	183	33	18.970	2.573	16.4	25.7
90	33	47.233	2.824	41.1	50.6	184	33	25.906	3.707	20.2	30.7
91	33	23.970	3.060	19.8	32.4	185	33	22.279	2.349	18.6	25.1
92	33	19.639	1.802	17.2	22.1	186	33	17.585	2.572	13.3	20.2
93	33	31.997	2.544	27.3	34.1	187	33	11.455	0.491	10.5	12.4
94	33	29.361	0.865	28.2	30.7	188	33	11.703	0.720	10.9	13.2

(Ritchie, 2023)