Understanding Policy Resistance in Tobacco Taxation Policy

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Abstract:

Many governments increase taxes on unhealthy products to reduce their consumption. Many countries have applied higher taxes on items like tobacco to make them more expensive and discourage people from buying them. For example, the Indian Government's GST Council is considering higher taxes on products like tobacco to make them more expensive. However, such tax policies do not always work as expected. This is because of policy resistance, where people and businesses find ways to adjust, reducing the impact of the tax. One common form of policy resistance is the rebound effect, where people shift to cheaper alternatives, buy from illegal markets, or continue using the product despite the higher price.

This exploratory study uses a system dynamics approach to understand why tobacco tax policies face resistance. System dynamics helps us see how different factors, such as consumer behavior and government actions, interact with each other over time. By studying these connections, we can understand why taxation alone may not be enough to reduce tobacco use.

Our study finds that simply increasing taxes may not always lead to lower tobacco consumption. The system has feedback effects that make it hard for tax policies to work as planned. To improve the impact of taxation, governments may need additional measures, such as stricter law enforcement, better awareness campaigns, and policies that help people quit tobacco.

This paper provides useful insights on the potential side effects of taxation policies and why there is a need to design better tax strategies that work in the long run. While our model uses the taxation policy of India as an example, the findings can help other countries facing similar challenges in controlling unhealthy products through taxation.

Introduction:

Many governments, including India, use taxes to try to reduce the use of harmful products like tobacco. The idea is that if tobacco becomes more expensive, people will buy less of it, and some may eventually quit. However, this linear cause-and-effect does not always play out this way in the real world. There are feedbacks between cause and effect. People and companies adjust their behavior to counter the tax effects. For example, many users switch to cheaper brands or even buy from illegal sources, and in respone, tobacco companies may be forced to change their prices or offer discounts. This adjustment, known as the "rebound effect," means that the tax does not reduce tobacco use as much as expected.

Tobacco use is a major health problem worldwide. It leads to serious diseases such as cancer, heart disease, and lung problems, which put a heavy burden on families and the

healthcare system. High rates of tobacco use cause many illnesses and premature deaths, and they also increase medical costs. In countries where a large number of people use tobacco in various forms, it is very important to design policies that work effectively. Understanding why tax policies sometimes fail helps us to create better strategies that can truly reduce tobacco use and improve public health.

Many existing studies on tobacco taxation focus only on the direct effect of higher prices on reducing consumption. They often overlook how consumers, businesses, and the market adjust to these changes. There is little research that looks at the complete picture, including the feedback loops and the rebound effect, especially in India. Not many studies use a system dynamics approach to analyze these interactions and the resulting policy resistance. This gap means that current research does not fully explain why tax policies sometimes do not work as expected, leaving a need for more detailed studies that can help design better policies.

Objectives

The objectives of this study are to:

1. Understand why increasing taxes on tobacco does not always lead to a significant drop in its use.
2. Explore how consumers change their behavior when taxes are increased.
3. Use a system dynamics approach to reveal feedback loops and the rebound effect that weakens the tax impact.
4. Provide recommendations for designing better tobacco tax policies.

Literature review

Tobacco taxation has been widely studied by researchers around the world. In many cases, studies have shown that increasing taxes on tobacco products can reduce consumption. For example, the work by (Chaloupka, 2012) shows that higher taxes make tobacco more expensive, which in turn leads to lower tobacco use. However, these studies often focus only on the immediate, direct effects of price increases. They tend to ignore how consumers, businesses, and the market as a whole adjust to these changes.

Another important piece of research by (Warner, 2000) highlights that the tobacco industry is not a passive player. When taxes are increased, companies may counteract the effect by offering discounts or lowering prices in other ways. This response can weaken the overall impact of the tax policy. Similarly, (Jha, 2000) has provided evidence that while tobacco

taxation has the potential to improve public health by reducing smoking-related diseases, the actual results in real-world scenarios are often less than expected. The reasons for this include the fact that many consumers switch to cheaper brands or move to the illegal market, where tobacco is sold without any tax.

To capture the complexity of tobacco taxation and its effects, our study uses a system dynamics approach. This method, as explained by (Sterman, 2000), is particularly useful for modeling systems that involve many interacting components and feedback loops. In a system dynamics model, we identify key variables (or "stocks") such as the number of smokers and the amount of legal and illegal tobacco sales. We then look at the flows—how these stocks increase or decrease over time—and the feedback loops that connect them.

In our model, we include different sectors: smoking behavior, government taxation, legal and illegal tobacco markets, crime, and community stress. The smoking behavior sector tracks how people start smoking, how they quit, and how many relapses. The government taxation section models how an increase in tax affects the price of cigarettes. The legal and illegal market sections capture how consumers choose between legal and illegal sources based on price and availability. The crime and community stress sections explore how the rise of illegal markets can lead to higher crime rates and increased stress in society.

We simulate the model over a period of 50 years. By doing so, we can observe the long-term effects of tobacco taxation policies and understand how different factors interact over time. We use data from various sources, including the Global Adult Tobacco Survey (GATS) (Tata Institute of Social Sciences (TISS), 2016-17) and studies conducted by well-known researchers, to calibrate our model. Although there are limitations—such as not including detailed demographic factors or healthcare costs—the model provides some insights into the overall dynamics of tobacco taxation in general.

The literature shows that while taxation is an effective tool in theory, its real-world implementation is fraught with challenges. These challenges arise from the complexity of human behavior and market adjustments. Our study builds on this literature by using system dynamics to reveal the feedback loops and unintended consequences that make tobacco tax policies less effective than intended.

Problem Statement

Despite significant efforts to reduce tobacco consumption through higher taxes, many countries continue to face high rates of smoking and tobacco use. The expected reduction in smoking rates from increased taxation has not fully materialized, largely due to policy resistance.

Conceptual Reference mode

The behavior-over-time graph (BOTG) for tobacco use after a tax hike has four interrelated curves:

1. **Legal Cigarette Sales**
   Right after Taiwan's 2002 tax hike (a 20% price rise), legal cigarette sales fell by about 15% in the first year, matching a 10.5% drop in per-person use (Lee JM, 2005). In India, when GST plus CESS came in 2017, legal sales also fell sharply—by about 4.5–13% in year one. (Goodchild M. V., 2020)

2. **Brand-Switching or "Down-Trading"**
   Many smokers did not quit but moved to cheaper options. In Taiwan, 70–80% of lower-income smokers began buying discounted brands within a year, while in India about 23% switched to bidis (Tsai Y. W., 2005); (Rout, 2020); (Tata Institute of Social Sciences (TISS), 2016-17). On the graph, this shows the number of smokers dropping fast at first and then tapering.

3. **Illicit Cigarette Sales**
   As legal prices went up, illegal sales rose quickly. In Taiwan, smuggling cases jumped five-fold in the first year, and in India illegal products make up about 12–15% of the market (Tsai Y. W., 2003); (DRI, 2020).

4. **Smoking Prevalence with Stress-Driven Relapse**
   The growing illegal market often leads to more crime and stress, causing some people who had quit to start again. In U.S. studies, chronic stress doubled relapse chances over two years, and in Delhi, stressed ex-smokers were 1.6 times more likely to relapse (Slopen, 2013); (Swasticharan L, 2022). On the graph, smoking prevalence falls most in years 1–2 and then slowly rises again.

When you put these curves together, you see a "quick-fix backfires" pattern: a big initial drop in legal sales and smoking, followed by a rise in illegal sales and relapse, which increases overall tobacco use over time. The figure below depicts this pattern.

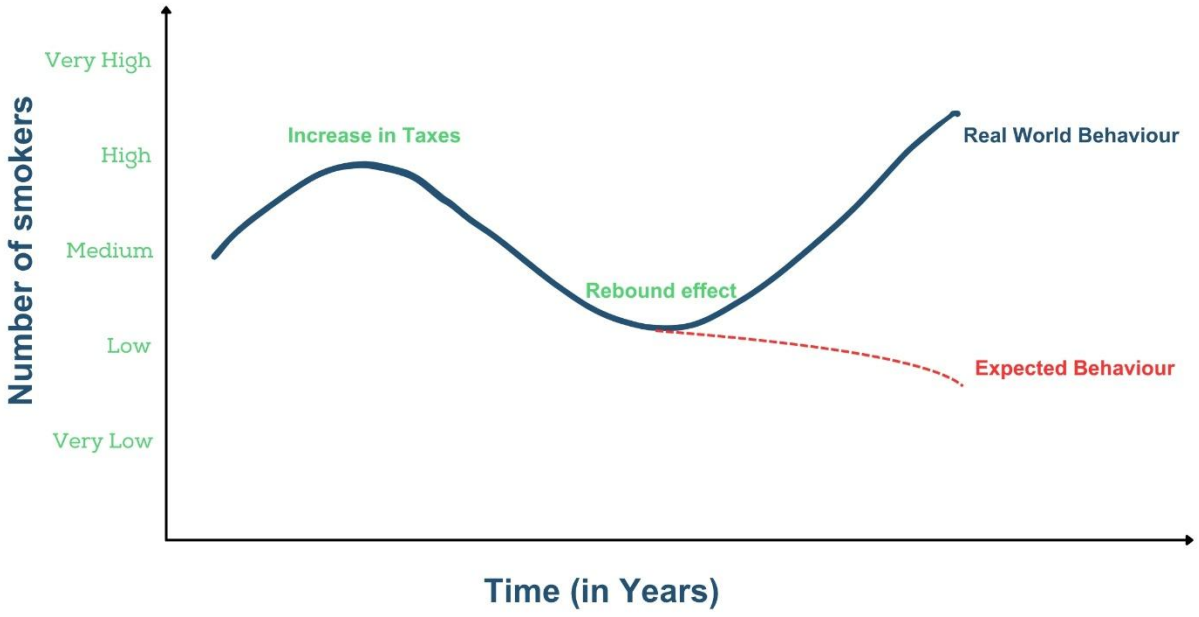

Figure 1: The figure shows the conceptual reference mode for the problem statement.

The behavior shown in Fig 1. presents a conceptual reference mode for tobacco consumption following the implementation of a taxation policy. The pattern is derived from empirical references from different places, reflecting expected dynamic behavior over time. While real-world variations are likely, this trend helps illustrate the potential for policy resistance due to unintended side-effects such as black-market growth and stress-induced relapse in smoking.

Dynamic Hypothesis (CLD):

This section explains the qualitative structure of the behaviour using a Causal Loop Diagram. The diagram helps us understand the different forces that work together to shape smoking patterns and the overall effects of tobacco taxation policies. Reducing smoking rates is a very important goal of the WHO Framework Convention on Tobacco Control (FCTC). This treaty, which has been ratified by 182 countries, was created to save lives and improve health around the world. The treaty highlights that reducing tobacco use is not only a matter of personal health but also a global public health issue.

Research has shown that higher tobacco taxes and prices are very effective in reducing tobacco use, especially among young people and people with lower incomes, who are more sensitive to price changes (WHO, 2024). The evidence supports the idea that a rise in

price can lead to a significant drop in consumption, making taxation a key strategy in tobacco control.

However, while high taxes help to reduce tobacco consumption in many cases, they can also have some unwanted side effects. If the enforcement of tax policies is weak, the increased cost of legal tobacco products may lead some smokers to look for cheaper alternatives. This situation creates an opportunity for the illicit tobacco trade to expand. When illegal markets flourish, not only does this undermine the impact of the tax policy, but it also reduces the government's tax revenue.

Additionally, when the illegal market expands, it usually leads to an increase in crime rates within communities. High crime rates and frequent instances of community violence create an environment of fear and anxiety among residents. Such stressful conditions are known to harm mental health and well-being (WHO, 2013). Stress is a very important factor in tobacco use. Many individuals turn to smoking as a way to cope with their stressful situations, which means that increased stress can actually lead to higher smoking rates (Stubbs, 2017).

In summary, while high taxes on tobacco products can reduce smoking by making it less affordable, they may also trigger a series of unintended consequences. The rise in illicit trade, increased crime, and higher community stress can all work together to weaken the overall benefits of the tax policy.

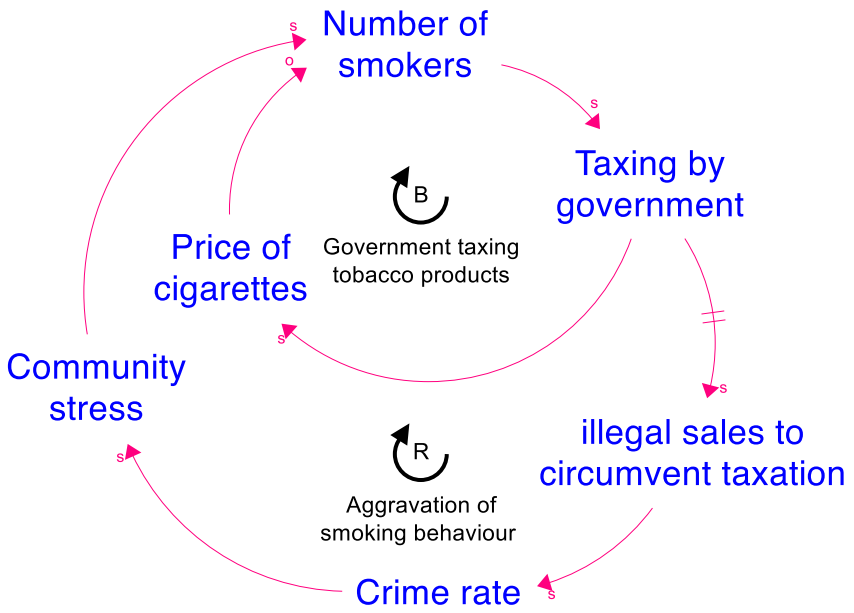

Figure 2: Causal Loop Diagram (CLD) representing the Dynamic Hypothesis (DH) of the study.

Model Boundary and Key Assumptions

This model is built using several assumptions that help simplify a very complex real-world situation. First, on the economic side, the model assumes that the tax structure remains stable over the simulation period. This means that the rules, such as Goods and Services Taxes (GST) for cigarettes and any additional cesses, do not change over time. It also assumes that any tax increase is fully passed on to the consumer, so the retail price of cigarettes goes up exactly by the tax increase. Additionally, the model does not explicitly include general inflation; instead, it captures the impact on affordability only through the tax-induced price change.

The model assumes that the demand for tobacco is moderately sensitive to changes in price, a relationship captured through the concept of price elasticity. Price elasticity of demand for tobacco products in India has been widely studied. One study estimates the elasticity of cigarette demand ranging from –0.2645 among the richest population segment to –0.832 among the poorest, suggesting that poorer consumers are more responsive to price changes (Selvaraj, 2015). A broader analysis reveals that the elasticity is generally higher in rural areas (–0.63) compared to urban areas (–0.49) (Adeniji, 2019). Combining these, the behavioral side, the model assumes that tobacco demand is somewhat sensitive to price changes. It uses a price elasticity ranging from -0.4 to -0.8. In simple terms, this means that a 10% increase in cigarette prices would reduce consumption by about 4% to 8%.

Another important behavioral assumption in the model is that a portion of smokers may turn to illegal sources of tobacco when legal prices rise significantly. Studies on illicit tobacco trade globally indicate that tax hikes often lead to increased demand for cheaper, untaxed alternatives. Although exact percentages vary by country and enforcement strength, international evidence suggests that between 10% and 25% of smokers may shift to illegal markets with every 10% increase in legal cigarette prices (Joossens, 2010). It does not assume that all smokers quit because of higher prices. Instead, some continue to smoke by reducing consumption, switching to cheaper brands, or even relapsing due to stress.

On the structural side, the model makes a few key assumptions about how different parts of the system interact. It assumes that the illegal tobacco market grows in proportion to tax-induced price increases. This means that if legal tobacco becomes too expensive, more people will turn to smuggled or counterfeit products. The model also includes a time delay; it assumes there is a delay between a policy change, like a tax increase, and when its effects on behavior, illegal trade, and stress become noticeable. Lastly, it assumes that law

enforcement effectiveness remains constant unless specifically changed in the model, meaning it does not improve over time by itself.

In addition to these assumptions, the model has some limitations. It does not account for detailed demographic differences, such as variations in income, education, or regional habits, which can all significantly influence smoking behavior. The model also does not include healthcare cost dynamics, so it does not show how smoking-related illnesses might burden the healthcare system or how reducing smoking could save medical costs. Additionally, it does not capture the effects of anti-smoking media campaigns or public education efforts, which can also have a strong influence on smoking rates. The assumption that tax increases are fully passed on to the consumer might not always be true in real life, where companies sometimes absorb part of the tax to keep prices lower. Finally, the fixed relationship assumed between illegal trade, crime, and community stress might be an oversimplification of how these factors interact in reality.

Future studies should work on refining these assumptions and addressing these limitations to better understand the full impact of tobacco control policies.

Model Structure:

Key Components:

Table 1: Details of Stocks and Flows in the model.

S.No	Stock	Units	Inflows	Inflow units	Outflow	Outflow units
1	Number of smokers	People	• People starting smoking. • Stress induced smoking growth. • People normal relapsing. • People stress induced relapsing.	People/year	• People general quitting rate. • People quitting due to increase in price. • People dying due to smoking	People/year
2	Total legal sales	packet	• Annual legal sales.	Packet/year	-	-
4	Government Revenue	INR	• Annual tax collection	INR/year	-	-
5	Total Illegal Sales	packet	• Annual illegal sales.	Packet/year	-	-
6	Total Crimes	incident	• Crime rate growth due to illegal sales	Incident/year	• Crime Suppression rate	Incident/year
7	Community stress levels due to crime growth	Stress unit	• Stress accumulating in the community	Stress unit/ year	• Recovery rate from stress	Stress unit/ year

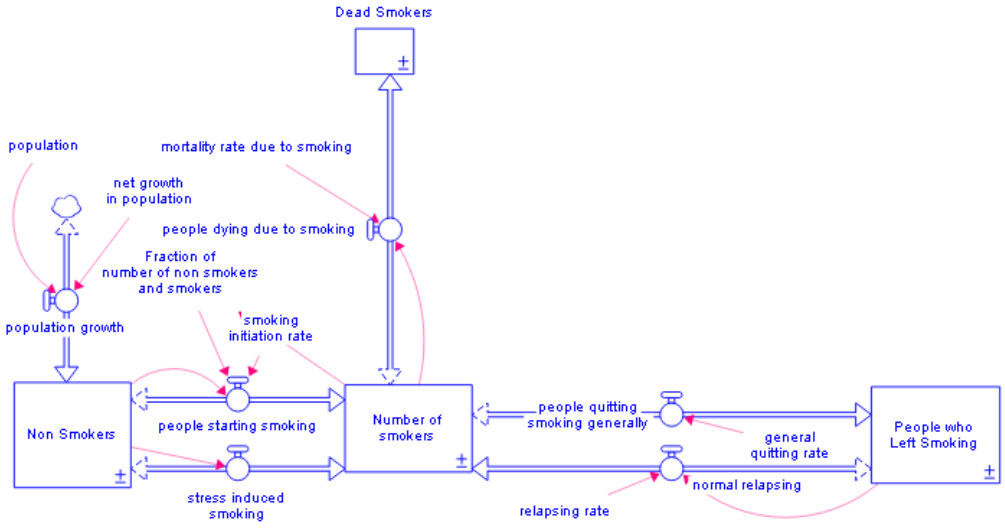

Figure 3: Model structure of smoking behaviour.

Smoking Behavior

At the heart of the model is the smoking behavior section. This section keeps track of the number of people who smoke. While the population growth adds to the growth in number of non-smokers, it is divided into different components:

- **People Starting Smoking:** This represents those who begin smoking due to social influence, peer pressure, or curiosity. In India, many young people might try smoking because it is seen as a part of social life or because they are influenced by friends or family.
- **Quitting Smoking:** Not all smokers continue indefinitely. Some people decide to quit smoking because of health concerns, the high cost of cigarettes, or personal decisions. The model captures both general quitting and quitting specifically due to an increase in cigarette prices.
- **Relapse and Stress Effects:** One of the unique aspects of our model is the inclusion of relapse. Even if someone quits smoking, they may start again later, especially when they are under stress. The model includes a delay mechanism to show that stress-induced smoking does not happen immediately but over time as community stress builds up.

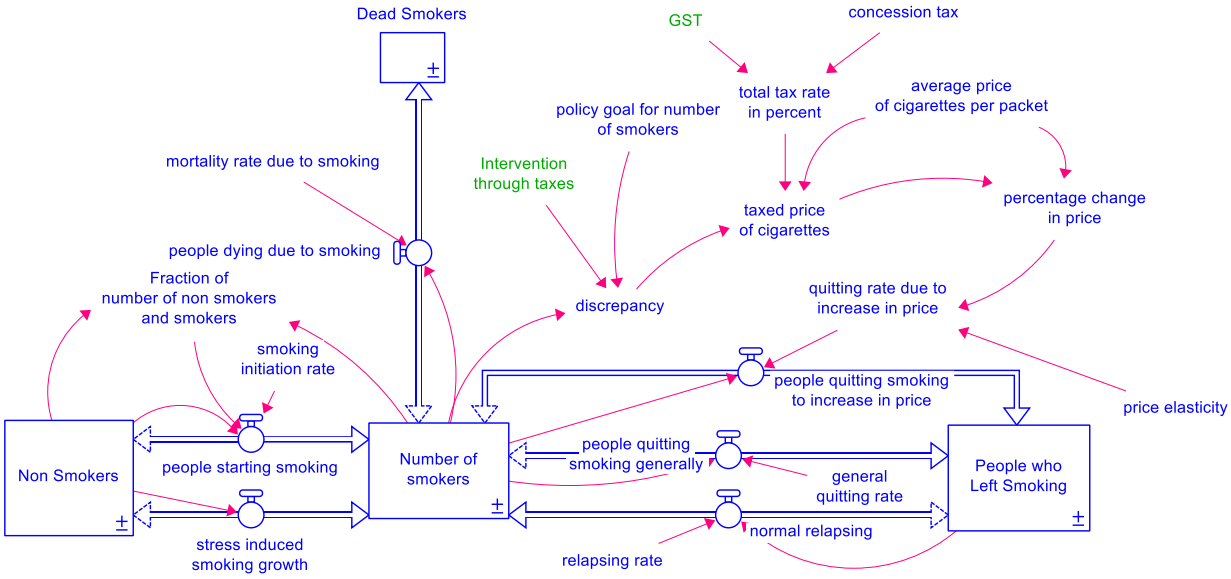

Figure 4: Model Structure of smoking behaviour along with government taxation. The tax is represented as GST in green colour.

Government Taxation

The next part of the model deals with government taxation. When the government raises taxes on tobacco products, the immediate effect is an increase in the price of cigarettes. This section of the model shows how an increase in the tax rate leads to a higher retail price. The idea is that a higher price should discourage smoking by making it less affordable for many people. However, as the model shows, the effect is not straightforward.

- **Price Elasticity:** The model uses a price elasticity parameter to determine how sensitive smokers are to changes in price. For instance, a small increase in price might cause only a few people to quit, while a larger increase might force more smokers to find alternatives.
- **Tax Pass-Through:** In our model, it is assumed that the full tax increase is passed on to the consumer, so the retail price of cigarettes goes up by the full amount of the tax increase.

Legal and Illegal Tobacco Markets

This section of the model is divided into two parts: the legal market and the illegal market.

- **Legal Market:** The legal market includes all tobacco sales that occur through

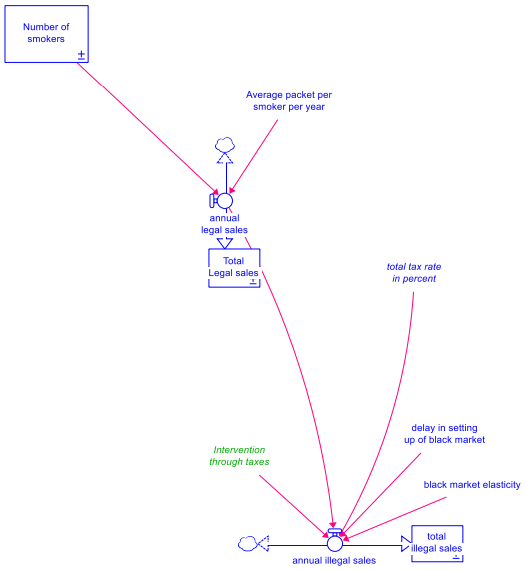

Figure 5: Model structure showing legal and illegal sales.

regulated channels. The government collects taxes from these sales, and these revenues are used for public services. The model calculates the total legal sales

based on the number of smokers and the average number of cigarette packets consumed per year.

- **Illegal Market:** As the price of legal cigarettes rises due to higher taxes, some consumers seek out cheaper alternatives from the illegal market. The illegal market is not regulated, and the government does not collect taxes from these sales. The model shows that as more people turn to illegal sources, the expected increase in government revenue from higher taxes is reduced. Moreover, the growth of the illegal market contributes to other societal problems.

Government Revenue

Finally, the model includes a section on government revenue. When tobacco is taxed, the government earns money from legal tobacco sales. However, if too many people switch to the illegal market, this revenue does not grow as expected. The model shows that:

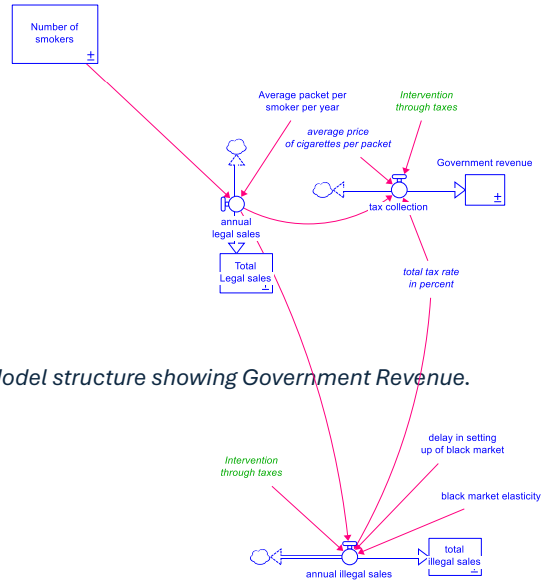

Figure 6: Model structure showing Government Revenue.

- **Short-Term Gains:** In the early stages, an increase in taxes results in higher revenue from legal sales.
- **Long-Term Losses:** Over time, as the illegal market expands, government revenue may plateau or even decline, because fewer people are buying from legal, taxed sources.

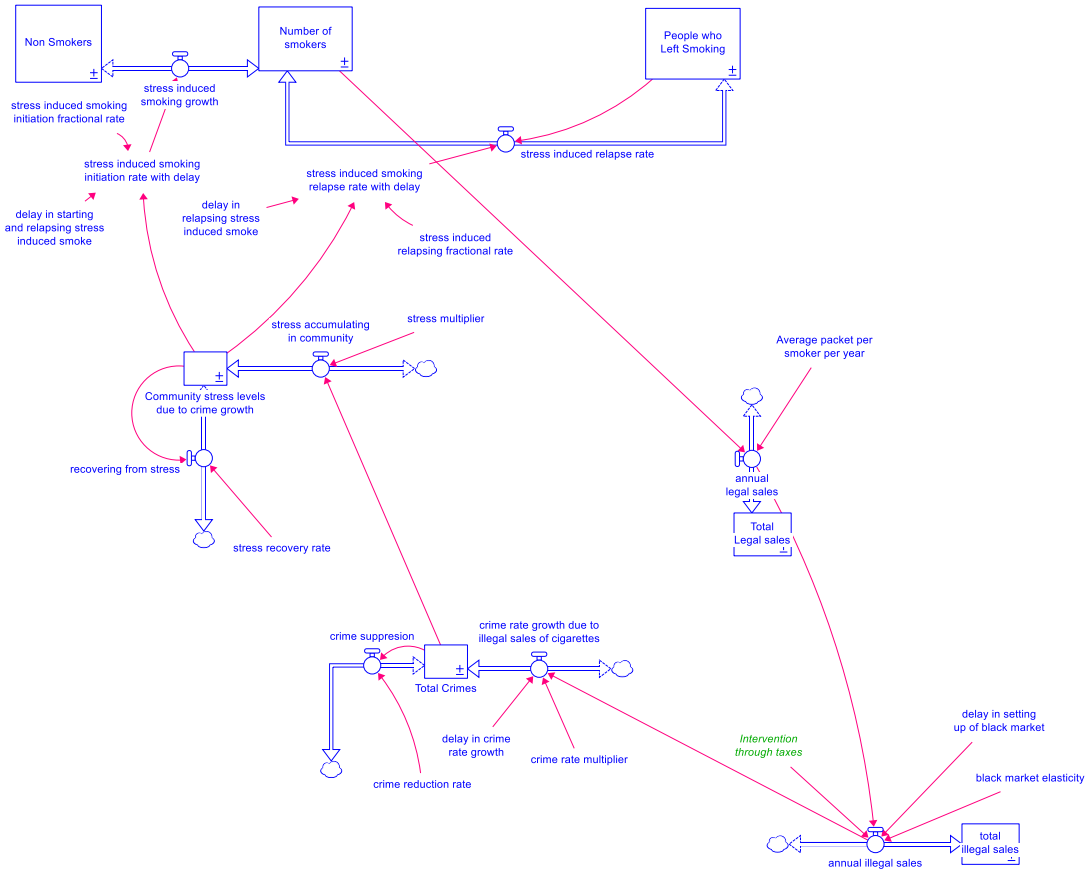

Figure 7: Model structure showing Crime and Community Stress.

Crime and Community Stress

An important aspect of our model is how the illegal tobacco market leads to increased crime and community stress. The relationship is modeled as follows:

- **Crime Increase:** When illegal tobacco sales grow, criminal organizations find it profitable to engage in activities such as smuggling and counterfeiting. This increase in illegal activities is represented in the model as a rise in crime incidents.
- **Community Stress:** As crime increases, community stress also rises. People in neighborhoods where crime is high feel unsafe and anxious. This increased stress can have multiple effects, including making some former smokers start smoking again as a way to cope.
- **Feedback Loops:** The model captures feedback loops where higher crime leads to greater community stress, and higher stress in turn may lead to more smoking. This creates a reinforcing cycle that makes it hard to reduce tobacco use by taxation alone.

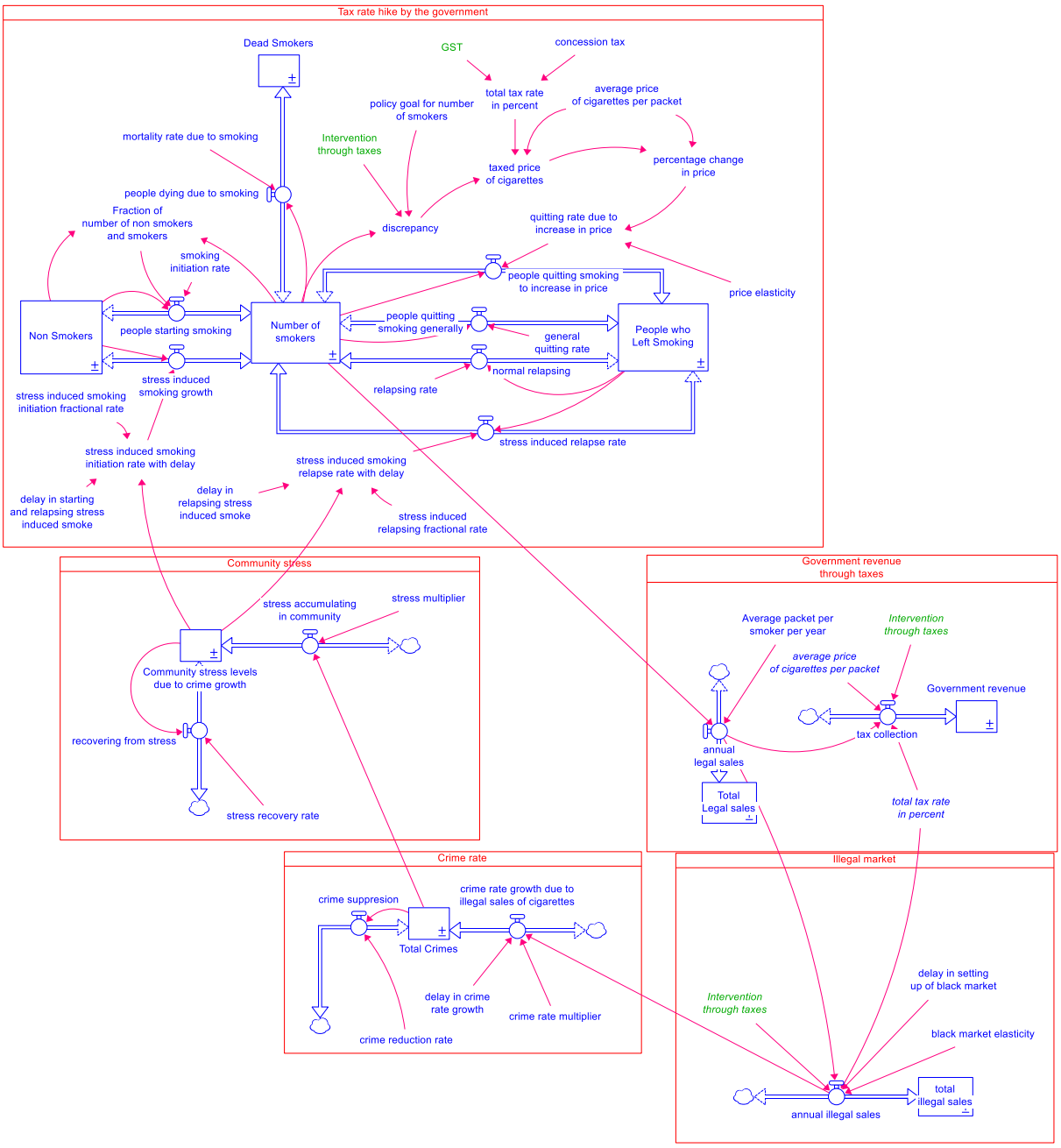

Figure 8: Overall model structure illustrating the five sectors: Tax rate hike by the government, Government revenue through taxes, Illegal market, Crime rate and Community stress.

Overall Structure and Interactions

The overall structure of the model has stocks and flows connected by feedback loops. The stocks represent the different quantities in the system (such as the number of smokers, legal sales, illegal sales, crime incidents, and community stress levels). The flows show

how these stocks change over time. For example, as more people quit smoking or switch to illegal markets, the stock of smokers decreases or the stock of illegal sales increases.

The key interactions in the model include:

- **Price-Consumption Loop:** Higher taxes increase cigarette prices, which should lead to lower consumption. However, the rebound effect and substitution to the illegal market weaken this relationship.
- **Illegal Trade and Crime Loop:** As more smokers turn to the illegal market, crime rates increase. Higher crime leads to more community stress, which in turn can cause more people to take up smoking again.
- **Revenue:** While increased taxes initially boost government revenue, the growth of the illegal market counteracts this benefit, reducing the overall effectiveness of the policy.

By examining these interactions, the model helps us understand the unintended consequences of relying solely on taxation to reduce tobacco use. It also shows the importance of a more balanced approach that includes law enforcement and public health measures.

Results and discussion

Business-As-Usual (BAU):

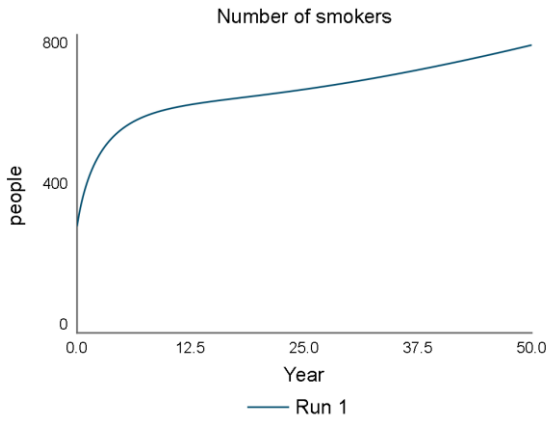

Figure 9: Graph (Run 1) showing the Business-As-Usual scenario. Y-axis shows Number of Smokers (in people) and X-axis shows Number of years (in year).

The above graph (Run 1) shows the Business-As-Usual (BAU) scenario for the number of smokers over a 50-year period. In this scenario, there is no strong government intervention, such as significant tax increases or public health campaigns, to reduce smoking. The graph begins with a moderate number of smokers at Year 0, then shows a rise in smoking over the first few years. This early increase happens because new smokers develop the habit, and there is no added policy pressure (like higher prices) to discourage the adoption.

The number of smokers increases rapidly in the early years, but the growth rate slows down over time. However, the total number of smokers continues to rise steadily, largely due to overall population growth. The BAU scenario maintains a relatively high level of smoking over time, illustrating what might happen if the government does not introduce stronger tobacco control policies.

Policy intervention:

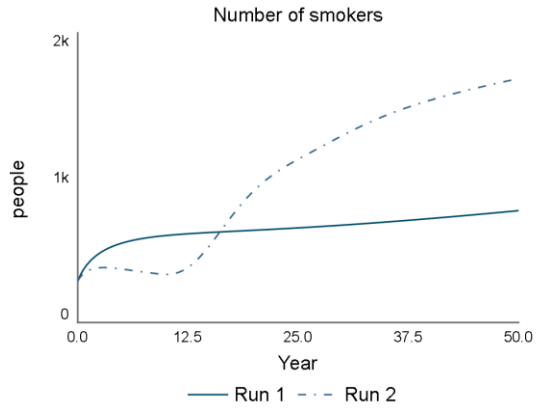

Figure 10: Graph (Run 2) showing 28% Tax scenario. Y-axis shows Number of Smokers (in people) and X-axis shows Number of years (in year).

28% GST Scenario: In Run 2, the government imposes a 28% Goods and Services Tax (GST) on tobacco products. As soon as the higher tax is introduced, the price of cigarettes rises significantly. Some smokers initially quit or reduce their consumption because of the sudden increase in cost, causing the number of smokers to dip slightly in the early years.

However, over time, more smokers begin to adjust to the higher price. Some switch to cheaper or illegal alternatives, which can weaken the impact of the tax policy. The chart shows that after an initial decrease, the number of smokers in Run 2 gradually climbs again. This happens because the illegal market expands, stress levels may increase, and

some former smokers relapse. By the end of the 50-year period, the curve in Run 2 levels off at a higher number than the lowest point reached shortly after the tax increase. Although the 28% GST scenario still maintains a reduced smoking rate compared to the very beginning, the long-term effect is not as strong as one might expect from a significant tax hike alone.

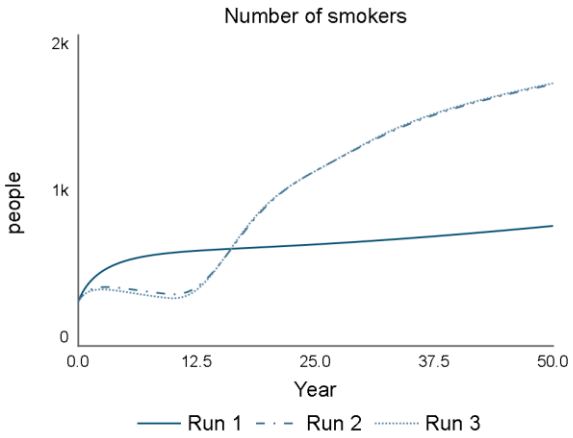

Figure 11: Graph (Run 3) showing the 35% Tax scenario. Y-axis shows Number of Smokers (in people) and X-axis shows Number of years (in year).

35 % GST Scenario: In Run 3, the government sets a higher tax rate of 35% GST on tobacco products, aiming to make cigarettes even more expensive and thereby discourage smoking more strongly than in lower-tax scenarios. Right after this policy takes effect, the model shows an immediate and noticeable dip in the number of smokers. This initial decline happens because many people find the new, higher prices too difficult to afford, prompting them to quit or reduce their tobacco consumption.

However, over time, the rebound effect becomes stronger in the 35% GST scenario compared to lower-tax cases. As the legal market becomes less attractive, more smokers seek cheaper, untaxed alternatives in the illegal market. This growth in illegal sales fuels organized crime and raises community stress levels, which can cause some former smokers to relapse. As a result, the number of smokers in Run 3 begins to climb again after the initial drop, eventually leveling off at a higher count than one might expect from such a steep tax rate.

Difference between Run 3 and Run 2: Statistically, the difference between run 3 and run 2 is low (Difference in number of smokers due to changing tax rate from 28% to 35%). However, in the real-world, the addition of every new smoker is a socially important indicator. In this case, the model shows a slight increase in the number of smokers due to

stronger policy resistance. Statistically, this rise may not seem big because the model is based on a small population size, but in the real world, the actual number of smokers runs into thousands or lakhs. So even a small percentage increase can mean a large number of people continuing to smoke or returning to smoking. This can lead to serious health consequences and put more pressure on the public healthcare system. Therefore, what seems like a small difference in the model can have major real-world effects.

Alternative policy design:

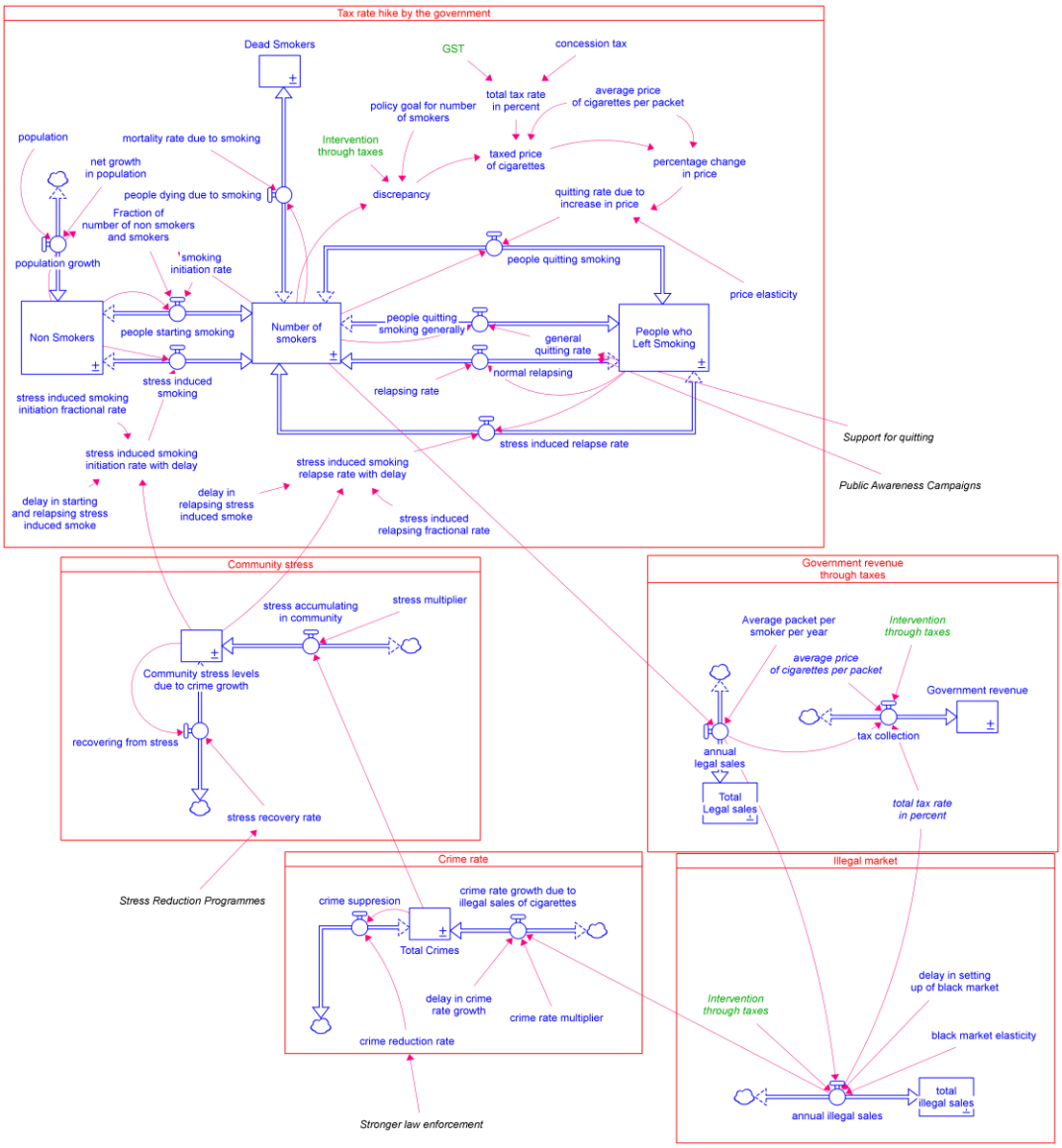

Figure 12: Overall model structure illustrating alternative policy measures showing Stronger Law Enforcement, Stress Reduction Programmes, Public Awareness Programmes and Support for Quitting. All the measures are marked in black.

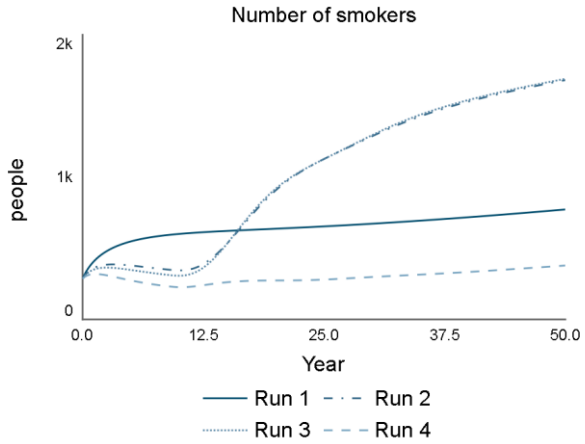

Figure 13: Graph (Run 4) showing the scenario with alternative policy measures. Y-axis shows Number of Smokers (in people) and X-axis shows Number of years (in year).

Run 4 shows the simulation of the alternative policy design scenario provides a more optimistic outlook. In this scenario, the government not only increases taxes on tobacco but also implements a range of supportive measures. The numbers in the supportive measures are calibrated through adjusting the levers of key parameters. These measures include:

1. **Stronger Law Enforcement:**
   To combat the growth of the illegal market, the government increases law enforcement efforts. This means better monitoring, stricter penalties for illegal sales, and improved border controls to prevent smuggling. With these measures in place, the illegal trade is kept in check, and more smokers are forced to purchase legal, taxed tobacco.
2. **Public Awareness Campaigns:**
   The government launches extensive public awareness campaigns to educate people about the health risks associated with tobacco use. These campaigns use simple messages and local languages to reach a wide audience. The aim is to change public attitudes towards smoking and to encourage smokers to quit.
3. **Support for Quitting:**
   Recognizing that quitting smoking is a difficult process, the government invests in programs that help smokers quit. These programs include counseling services, nicotine replacement therapies, and support groups. By providing these resources, the government makes it easier for smokers to overcome their addiction.
4. **Stress Reduction Programmes:**
   In addition to the above measures, the government introduces stress reduction programmes to help communities cope with the pressures that may lead to tobacco

use. These programmes include community-based mental health support, regular stress management workshops, and the creation of recreational facilities where people can engage in physical activities and relaxation techniques. By providing access to counselling services and mindfulness sessions, these programmes aim to reduce the overall stress levels in communities. Lower stress levels help individuals avoid turning to tobacco as a coping mechanism, thus supporting the overall goal of reducing smoking rates.

With these combined measures, the simulation shows a significant drop in smoking rates over the long term. The number of legal tobacco sales declines steadily, while the illegal market remains under control. Crime rates decrease, and community stress levels begin to fall as people feel safer and more supported. Government revenue, while initially affected by the shift in consumer behavior, stabilizes as the overall system becomes more balanced.

Scope for further research, and limitations of this study

In conclusion, our study shows that increasing taxes on tobacco alone is not enough to significantly reduce smoking. The system dynamics model reveals that several interconnected factors-such as consumer behavior, illegal trade, crime, and community stress-work together to create a situation of policy resistance. This resistance, exemplified by the rebound effect and the growth of the illegal market, prevents tobacco tax policies from achieving their full potential in reducing smoking rates.

This exploratory study demonstrates that a more effective approach is to combine higher taxes with additional measures. These measures include stronger law enforcement to control illegal trade, public awareness campaigns to educate people about the health risks of smoking, and comprehensive support systems to help smokers quit.

The solution numbers and policy recommendations presented in this study are derived from simulation runs using a system dynamics model built in STELLA Architect. These values are not direct representations of real-world measurements but are generated by adjusting key policy levers (e.g., taxation rate, enforcement strength, awareness investment) within the model to observe behavioral patterns and system responses over time. The numbers help illustrate how different feedback loops interact and where policy resistance may arise. While they offer useful insights into possible dynamics, these values should be interpreted as conceptual approximations rather than empirical predictions. Further research using field data would be needed to calibrate the model for precise forecasting or intervention design.

In the future, the model can be improved by representing different groups of smokers separately using arrays. At present, all smokers are combined into a single stock, but in reality, different groups - such as youth, adults, low-income individuals, or users of different tobacco types - respond differently to tax increases. For example, younger people may be more likely to quit, while older or lower-income smokers may switch to cheaper or illegal alternatives. By dividing the population into such categories, the model can assign different behaviours, such as varying quitting rates or price sensitivities, to each group. This will allow for a more detailed understanding of how taxation policies affect different sections of society and help design more targeted and effective interventions. Future research can also explore the role of media and advertising restrictions in reducing tobacco use. These studies could help determine whether more aggressive anti-smoking campaigns would further reinforce the benefits of taxation and other measures. In addition, more studies are needed to evaluate the effectiveness of various public awareness and quitting support programs in different countries and different parts within a country.

Our study makes it clear that a single policy, such as raising tobacco taxes, cannot solve the complex problem of tobacco use on its own. A multi-faceted approach that addresses the underlying causes of policy resistance is necessary. With systemic planning and a coordinated effort across different sectors, it is possible to design tobacco control policies that not only discourage smoking but also improve the overall well-being of society.

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Model Equations:

	Equation	Properties	Units	Documentation
total_packets_sold	total_illegal_sales + Total_Legal_sales		packet	
Total_Population	Dead_Smokers + Non_Smokers + Number_of_smokers + People_who_Left_Smoking		people	
Community_stress:				
Community_stress_levels_due_to_crime_growth(t)	Community_stress_levels_due_to_crime_growth(t - dt) + (stress_accumulating_in_community - recovering_from_stress) * dt	INIT Community_stress_levels_due_to_crime_growth = 0	stress unit	
recovering_from_stress	Community_stress_levels_due_to_crime_growth*stress_recovery_rate		stress unit/Year	
stress_accumulating_in_community	Total_Crimes*stress_multiplier/DT		stress unit/Year	
stress_multiplier	2		stress unit/incident	
stress_recovery_rate	0.1 + Stress_Reduction_Programmes		1/year	

Crime_rate:				
crime_rate_growth_due_to_illegal_sales_of_cigarettes	DELAY(crime_rate_multiplier*annual_illegal_sales, delay_in_crime_rate_growth, 0)		incident/Year	
crime_rate_multiplier	5*10^-7		incident/packet	
crime_reduction_rate	0.15 + Stronger_law_enforcement		per year	
crime_suppresion	Total_Crimes*crime_reduction_rate		incident/Year	
delay_in_crime_rate_growth	2		year	
Total_Crimes(t)	Total_Crimes(t - dt) + (crime_rate_growth_due_to_illegal_sales_of_cigarettes - crime_suppresion) * dt	INIT Total_Crimes = 0	incident	
Government_revenue_through_taxes:				
annual_legal_sales	Average_packet_per_smoker_per_year*Number_of_smokers		packet/Year	
Average_packet_per_smoker_per_year	200		packet/people/year	
Government_revenue(t)	Government_revenue(t - dt) + (tax_collection) * dt	INIT Government_revenue = 0	INR	
tax_collection	IF Intervention_through_taxes =1 THEN (annual_legal_sales*total_tax_rate_in_percent*average_price_of_cigarettes_per_packet) ELSE 0		INR/Year	
Total_Legal_sales(t)	Total_Legal_sales(t - dt) + (annual_legal_sales) * dt	INIT Total_Legal_sales = initial_legal_sales	packet	
Illegal_market:				
annual_illegal_sales	IF Intervention_through_taxes = 1 THEN DELAY((annual_legal_sales*total_tax_rate_in_percent*black_market_elasticity), delay_in_setting_up_of_black_market, 0) ELSE 0		packet/Year	
black_market_elasticity	0.2		unitless	
delay_in_setting_up_of_black_market	5		year	
total_illegal_sales(t)	total_illegal_sales(t - dt) + (annual_illegal_sales) * dt	INIT total_illegal_sales = initial_illegal_sales	packet	
Initial_values_in_stocks:				
initial_black_market_size	0		packet	
initial_community_stress	0		stress unit	
initial_crime_rate	0		incident	

initial_government_tax_revenue	0		INR	
initial_illegal_sales	0		packet	
initial_legal_sales	0		packet	
initial_non_smokers	1000		people	According to the Global Adult Tobacco Survey (GATS) conducted in 2016–17, the overall prevalence of smoking tobacco use is 10.38% and smokeless tobacco use is 21.38% in India. Of all adults, 28.6% currently consume tobacco either in smoke or smokeless form, including 42.4% of men and 14.2% of women. GATS 2: Global Adult Tobacco Survey - India 2016-17
initial_number_of_smokers	0.286*1000		people	https://www.who.int/india/health-topics/tobacco#:~:text=Nearly%20267%20million%20adults%20(15,Survey%20India%2C%202016%2D17. According to the Global Adult Tobacco Survey (GATS) conducted in 2016–17, the overall prevalence of smoking tobacco use is 10.38% and smokeless tobacco use is 21.38% in India. Of all adults, 28.6% currently consume tobacco either in smoke or smokeless form, including 42.4% of men and 14.2% of women. GATS 2: Global Adult Tobacco Survey - India 2016-17
Levers:				
simulation_duration	50		year	
Measures:				
Measures_lever	0		unitless	
Public_Awareness_Campaigns	IF Measures_lever = 1 THEN 0.025 ELSE 0		per year	
Stress_Reduction_Programmes	IF Measures_lever = 1 THEN 0.5 ELSE 0		Per Year	
Stronger_law_enforcement	IF Measures_lever = 1 THEN 0.5 ELSE 0		Per Year	
Support_for_quitting	IF Measures_lever=1 THEN 0.025 ELSE 0		Per Year	
Tax_rate_hike_by_the_government:				
average_price_of_cigarettes_per_packet	100		INR/packet	
concession_tax	0.12		unitless	
Dead_Smokers(t)	Dead_Smokers(t - dt) + (people_dying_due_to_smoking) * dt	INIT Dead_Smokers = 0	people	
delay_in_relapsing_stress_induced_smoke	2		year	
delay_in_starting_and_relapsing_stress_induced_smoke	2		year	
discrepancy	IF Intervention_through_taxes = 1 THEN Number_of_smokers-policy_goal_for_number_of_smokers ELSE 0		People	
Fraction_of_number_of_non_smokers_and_smokers	Non_Smokers/Number_of_smokers		unitless	

general_quitting_rate	0.05 +Support_for_quitting +Public_Awareness_Campaigns		per year	
GST	0.35		unitless	
Intervention_through_taxes	1		unitless	
mortality_rate_due_to_smoking	0.005		1/year	
Non_Smokers(t)	Non_Smokers(t - dt) + (- stress_induced_smoking_growth - people_starting_smoking) * dt	INIT Non_Smokers = initial_non_smokers	people	
normal_relapsing	People_who_Left_Smoking *relapsing_rate		people/Year	
Number_of_smokers(t)	Number_of_smokers(t - dt) + (people_starting_smoking + stress_induced_smoking_growth + normal_relapsing + stress_induced_relapse_rate - people_quitting_smoking_generally - people_dying_due_to_smoking - people_quitting_smoking_to_increase_in_price) * dt	INIT Number_of_smokers = initial_number_of_smokers	people	
people_dying_due_to_smoking	mortality_rate_due_to_smoking*Number_of_smokers		people/Year	
people_quitting_smoking_generally	Number_of_smokers*general_quitting_rate		people/Year	
people_quitting_smoking_to_increase_in_price	quitting_rate_due_to_increase_in_price*Number_of_smokers		people/Year	
people_starting_smoking	smoking_initiation_rate*Non_Smokers*Fraction_of_number_of_non_smokers_and_smokers		people/Year	
People_who_Left_Smoking (t)	People_who_Left_Smoking (t - dt) + (people_quitting_smoking_generally + people_quitting_smoking_to_increase_in_price - normal_relapsing - stress_induced_relapse_rate) * dt	INIT People_who_Left_Smoking = 0	people	
percentage_change_in_price	((taxed_price_of_cigarettes - average_price_of_cigarettes_per_packet)/average_price_of_cigarettes_per_packet)		unitless	
policy_goal_for_number_of_smokers	0		people	

price_elasticity	0.4		1/year	
quitting_rate_due_to_increase_in_price	price_elasticity*percentage_change_in_price		Per Year	
relapsing_rate	0.05		1/year	
smoking_initiation_rate	0.05		per year	
stress_induced_relapse_rate	stress_induced_smoking_relapse_rate_with_delay*People_who_Left_Smoking		people/Year	
stress_induced_relapsing_fractional_rate	0.005		1/stress unit/year	
stress_induced_smoking_growth	(stress_induced_smoking_initiation_rate_with_delay* Non_Smokers)		people/Year	
stress_induced_smoking_initiation_fractional_rate	0.005		1/stress unit/year	
stress_induced_smoking_initiation_rate_with_delay	DELAY(stress_induced_smoking_initiation_fractional_rate*Community_stress_levels_due_to_crime_growth , delay_in_starting_and_relapsing_stress_induced_smoke, 0)		per year	
stress_induced_smoking_relapse_rate_with_delay	DELAY(stress_induced_relapsing_fractional_rate*Community_stress_levels_due_to_crime_growth, delay_in_relapsing_stress_induced_smoke, 0)		per year	
taxed_price_of_cigarettes	IF discrepancy>=1 THEN average_price_of_cigarettes_per_packet+total_tax_rate_in_percent*average_price_of_cigarettes_per_packet ELSE average_price_of_cigarettes_per_packet		INR/packet	
total_tax_rate_in_percent	GST+concession_tax		unitless	