# MODELING THE IMPACTS OF TOBACCO TAX INCREASES IN MONTENEGRO

## A SIMULATION MODEL

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## Research objective:

The main objective of this research is to establish an evidence base for the impact of future tobacco excise tax increases on tobacco consumption, government revenues, smoking prevalence, and deaths averted due to price increases in Montenegro. The simulation analysis will allow policymakers to answer multiple "what if" questions, thus anticipating the various effects of different changes in tobacco taxes. The impacts are assessed in terms of increased government revenues, reduced tobacco consumption, and lives saved.

## The Tobacco Market in Montenegro: Background data

The proposed model considers impacts in two domains: government revenues and public health. In order to gain a more realistic insight into the tobacco market in Montenegro, the simulation related to public revenues is conducted according to cigarette market segments (premium, mid-price, and economy). The following sections describe the input data and assumptions of the model, which provides projections for the years 2024 and 2025. The complete methodology is described in the Appendix.

### IMPACT OF PRICE CHANGES ON REVENUES

The following assumptions are made regarding the first part of the simulations:

| Indicator | Assumption | Source |
|---|---|---|
| Tax burden | Baseline value is based on the 2023 tax structure | Ministry of Finance |
| VAT | 17.4 percent share in retail price | Ministry of Finance |
| Point elasticity of price | Used for calculating quantities after a tax and price change | Mugosa et al., 2020[1] |
| Cross-price elasticities by segments (switching between brands) | Calculated according to the available literature, due to unavailability of these estimates for Montenegro | Tauras et al., 2006 [2]; Delipalla et al., 2022[3] |
| Size of illicit market | Constant in observed period | Authors' assumption |
| Excise tax | Consists of a specific tax and an ad valorem tax | Ministry of Finance |
| Net-of-tax (NOT) | Increases by 5 percent for all market segments to account for the full pass-through effect (the increase in industry costs) | Authors' assumption |
| Gross domestic product (GDP) growth | 4.2 percent, 2.8 percent, and 2.8 percent in 2023, 2024, and 2025, respectively | International Monetary Fund (IMF) projections |

**Note:** The assumption of NOT change varies from 3 to 7 percent but does not impact the final results.

Input data include:

- data observed within different market segments (premium, mid-price, and economy):
  - retail price per pack of 20 cigarettes
  - cigarette consumption

1 Mugosa, A., Cizmovic, M., Lakovic, T. & Popovic, M. (2020) Accelerating progress on effective tobacco tax policies in Montenegro. Tobacco Control; 29(s5), 293-299 https://doi.org/10.1136/tobaccocontrol-2019-055197

2 Tauras, J.A, Peck, R.M & Chaloupka, F.J. (2006). The Role of Retail Prices and Promotions in Determining Cigarette Brand Market Shares. Review of Industrial Organization, 28(3), 253–284. http://www.jstor.org/stable/41799288

3 Delipalla, S., Koronaiou, K., Al-Lawati, J. A., Sayed, M., Alwadey, A., AlAlawi, E. F., Almutawaa, K., Hussain, A. H. J., Al-Maidoor, W., & Al-Farsi, Y. M. (2022). The introduction of tobacco excise taxation in the Gulf Cooperation Council Countries: A step in the right direction of advancing public health. BMC Public Health, 22(1):737. doi: 10.1186/s12889-022-13190-0. PMID: 35418055; PMCID: PMC9006469.

- tax revenues
- own-price elasticity, income elasticity, and cross-price elasticity
- net-of-tax price;

- excise tax rates–specific and ad valorem; and
- value-added tax (VAT).

The Tobacco Agency provided the data on price and quantity by brands of cigarettes from 2009–2022, which was used to determine market segments. As there is no official tobacco market segmentation, the segments were determined according to the price of cigarettes in 2022: the mid-price segment encompasses mainly most-sold brands, with the price ranging from 2.4 to 2.6 euros (close to the weighted average price of cigarettes in 2022), while the economy and premium segments include all brands with prices lower or higher, respectively, relative to the mid-price segment. For the most accurate predictions, 2023 is considered as the base year for the simulations, taking into account the available data on consumption and prices from 2022 (which are also used to estimate segments in 2024 and 2025).

Input data related to cigarette price structure–such as the average retail price per pack, excise taxes, and VAT, as well as baseline cigarette consumption (which is calculated based on issued excise stamps)–are obtained from the Ministry of Finance.[4] The Customs Administration provided data on excise revenues, while the gross domestic product (GDP) growth rate projections are available on the IMF and the World Bank websites. Necessary model parameters–such as smoking prevalence and own-, cross-price, and income elasticities–are obtained from the authors' research findings and a review of the literature.

The average retail price per pack in the baseline year 2023 is assumed to be at the level of 2.7 euros, and according to the previously defined excise tax calendar the specific tax amount is 47.5 euros per 1,000 cigarettes.[5] The VAT rate is 21 percent. The model assumes that the specific excise tax will be 51 euros per 1,000 cigarettes beginning on 1 January 2024, which is an additional increase of 3.5 euros compared to the previous year. The same pattern is followed in 2025. In all years, the ad valorem rate is assumed to stay constant at 26 percent of the weighted average price of cigarettes (WAPC). WAPC increases by 10 cents in 2024 and again in 2025. Table 1 presents the tobacco tax structure used in the simulation model.

**Table 1.** Tobacco taxes 2023–2025 (in euros)

| Description | 2023 | 2024 | 2025 |
|---|---|---|---|
| Specific excise tax per pack | **0.95** | **1.02** | **1.09** |
| Ad valorem | 26.0% | 26.0% | 26.0% |
| Minimum excise per pack | 1.65 | 1.75 | 1.84 |
| VAT | 21% | 21% | 21% |

To simulate cigarette price changes, the NOT price is assumed to increase by five percent across all market segments. The increase can be attributable to the increase in industry costs.

Due to the lack of data specific to Montenegro, price and income elasticities by market segments are assumed according to the available literature. Currently, ISEA research provides the results for total unconditional elasticities of -0.8 (price) and 0.63 (income). From the empirical evidence, it can be concluded that premium brands' total demand is less sensitive to price changes compared to the mid- and economy-price brands.

For example, estimates show that the demand of the economy market segment is three times more responsive to own-price changes as the premium market segment (Tauras et al., 2006). There are similar findings on the market segments and their sensitivity to price changes in research from the Gulf Cooperation Council

4 Ministry of Finance https://www.gov.me/en/mif

5 Excise Law in Montenegro https://www.gov.me/dokumenta/abb0b881-ef6d-4055-8fc2-06fb9d3c01d4

countries (Delipalla et al., 2022), though the estimated difference between segments is somewhat lower: the economy market segment is two times more responsive to own-price changes compared to the premium market segment. For these reasons, a sensitivity analysis is applied with different assumptions regarding the own-price elasticities across market segments.

The foundation for the estimates shown in Table 2 is the existing results of the ISEA research on unconditional elasticity in the Montenegrin tobacco market (-0.8 price elasticity). Specifically, unconditional elasticity is used for the mid-price segment and adjusted for the premium- and economy-price segments based on the ratio between own-price elasticities according to Delipalla et al., 2022.

**Table 2.** Different scenarios of own-price elasticities by market segments

| Market segments | Scenario I | Scenario II |
|---|---|---|
| Premium | -0.52 | -0.44 |
| Mid-price | -0.80 | -0.80 |
| Economy | -1.00 | -1.10 |

**Note:** Price elasticity measures the sensitivity of the quantity of tobacco products demanded in response to price changes. For example, if the price increases by 10 percent, cigarette consumption will decrease by 8 percent (price elasticity -0.8).

To obtain more precise results for changes between market segments, the model includes cross-price elasticities, measuring the change in demand of one segment when the price of another segment changes. The importance of this elasticity is that it measures the substitution between brands, which will affect government revenues as smokers transition to cheaper brands. Due to the unavailability of cross-price elasticity estimates in Montenegro, the model uses the assumed value of shifting to cheaper brands according to available empirical evidence (Tauras et al., 2006; Delipalla et al., 2022).

As shown in Table 3, it is assumed that the cross-price elasticity for the mid-price segment with respect to the premium segment is 0.8, which implies that a 10-percent increase in the price of premium brands would increase consumption of mid-price brands by approximately eight percent. Additionally, the cross-price elasticity for the economy-price segment with the respect to the mid-price segment is 0.25. This means that a 10-percent increase in the price of mid-price cigarettes would increase consumption of economy-price cigarettes by 2.5 percent. Constant illicit market share is assumed for each year of the simulation.

**Table 3.** Cross-price elasticities by market segments

| Market segments | Premium | Mid-price | Economy |
|---|---|---|---|
| Cross-price elasticity –premium | - | 0.80 | 0.30 |
| Cross-price elasticity – mid-price | 0.45 | - | 0.25 |
| Cross-price elasticity – economy | 0.10 | 0.20 | - |

To check for the potential differences or similarity of the results (due to characteristics of the Montenegrin tobacco market), the Results section provides the simplified simulation version, only accounting for consumers' transition or shifting between cigarette brands from premium to mid-price and from mid-price to economy, as well as the simulation version that accounts for cross-price effects between all price tiers (that is, cross-price elasticity of the premium segment with respect to the economy segment and vice versa, etc.).

The model also considers income elasticity, due to the impact of income on affordability of tobacco products. The estimated unconditional income elasticity equals -0.63, and—as in the case of own-price elasticity (Delipalla et al., 2022) - the difference in sensitivity of consumption due to income changes by segments are assumed as follows:

**Table 4.** Income elasticities by market segments

| Market segments | Scenario I | Scenario II |
|---|---|---|
| Premium | 0.41 | 0.13 |
| Mid-price | 0.63 | 0.63 |
| Economy | 0.79 | 0.87 |

## IMPACT OF PRICE CHANGES ON PUBLIC HEALTH BENEFITS

The following assumptions are made regarding the second part of the simulations:

- The percentage of adult quitters who avoid premature death (reduced risk from cessation) is 70 percent.[6]
- The percentage of smokers (adult and youth) who would die prematurely from diseases caused by smoking is 40 percent.
- In case there are no available estimates of elasticities related to the youth population, the assumption of a higher elasticity is applied for this group using the youth elasticity multiplication factor, which commonly equals 2.
- Total adult population is constant across years.

The baseline scenario (Table 5) includes the data on number of adults (ages 15+) and youth (ages 0–14) in the population, adult smoking prevalence (adult prevalence is used as expected prevalence for youth), total consumption, smoking prevalence elasticity,[7] youth elasticity multiplication factor, and number of deaths.

**Table 5.** Baseline parameters (input data) for simulation of price changes on public health benefits

| | |
|---|---|
| Total adult population (ages 15+) | 506,880 |
| Total youth population (ages 0–14) | 110,803 |
| Initial smoking prevalence (%) for the adult population ($SP_0$) | 31 |
| Total consumption in millions of packs ($Q_0$) | 56.86 |
| Prevalence elasticity | -0.521 |

**Notes:** Total population and number of deaths are obtained from the Statistical Office Monstat, while the Tobacco Agency provided the data on consumption. Smoking prevalence and prevalence elasticity are taken from ISEA research. The data are available only for 2022, but will be used as a baseline in 2023.

6 Burki, S. J., Pasha, A. G., Pasha, H. A., John, R., Jha, P., Baloch, A. A., Kamboh, G. N., Cherukupalli, R., & Chaloupka, F. J. (2013). The ecnomics of tobacco and tobacco taxation in Pakistan. Paris: International Union Against Tuberculosis and Lung Disease.
Quimbo, S. L. A., Casorla, A. A., Miguel-Baquilod, M., Medalla, F. M., Xu, X., & Chaloupka, F. J. (2012). The economics of tobacco and tobacco taxation in the Philippines. Paris: International Union Against Tuberculosis and Lung Disease.
Yürekli, A., Önder, Z., Elibol, M., Erk, N., Cabuk, A., Fisunoglu, M., Erk, S. F., & Chaloupka, F. J. (2010). The economics of tobacco and tobacco taxation in Turkey. Paris: International Union against Tuberculosis and Lung Disease.

7 If there are no available data on smoking prevalence elasticity, the data can be estimated applying the corresponding prevalence elasticity share, commonly equaling 0.5 of total demand elasticity (unconditional elasticity).

# IMPACT OF PRICE CHANGE ON REVENUES

## Scenario I

According to the given assumptions of specific excise tax changes from 2023–2025 and consequent price changes, Table 6 presents the results regarding the changes in consumption and government revenues (simplified simulation version of shifting to cheaper brands, from premium to mid-price and from mid-price to economy). The baseline is given for year 2023, whereas the quantity of cigarette packs sold is defined according to the average price of cigarettes determined by the market segments.

Throughout both simulated years there is an evident increase in total tax revenues: 2.5 percent and 2.3 percent in 2024 and 2025, respectively. The increase in excise taxes is shown to be the most efficient tool in reducing tobacco use, which at the same time causes an increase in government revenues. Even with the small change in price in 2024 (by 4.8 percent), the positive effects are evident through decreased consumption and increased government revenues. This leads to the conclusion that the Government of Montenegro needs to accelerate the changes to tobacco excise taxes to fulfill all set goals regarding tobacco control policies and the World Health Organization Framework Convention on Tobacco Control (WHO FCTC) requirements.

**Table 6.** Excise tax change impacts on government revenues – simulation results, Scenario I

| TOTALS (in millions of euros) | | | | | |
|---|---|---|---|---|---|
| **Market segment** | **Price/ pack** | **Quantity, packs (millions)** | **Excise revenue** | **Excise + VAT revenue** | **Market value** |
| **YEAR 2023 (Baseline)** | | | | | |
| Premium | 3.4 | 10,519,365 | 19,292,515 | 25,499,810 | 35,765,841 |
| Mid-price | 2.6 | 33,207,115 | 54,858,154 | 69,842,522 | 86,338,499 |
| Economy | 2.3 | 13,135,005 | 21,699,028 | 26,942,175 | 30,210,512 |
| Total or average (weighted) | 2.7 | 56,861,485 | 95,849,698 | 122,284,507 | 152,314,852 |
| **YEAR 2024** | | | | | |
| Premium | 3.6 | 8,660,200 | 16,961,241 | 22,386,688 | 31,260,909 |
| Mid-price | 2.7 | 33,726,562 | 58,954,031 | 75,037,323 | 92,670,399 |
| Economy | 2.4 | 12,844,295 | 22,451,828 | 27,874,358 | 31,244,102 |
| Total or average (weighted) | 2.8 | 55,231,057 | 98,367,099 | 125,298,368 | 155,175,410 |
| **% change** | **4.8%** | **-2.9%** | **2.6%** | **2.5%** | **1.8%** |
| **YEAR 2025** | | | | | |
| Premium | 3.8 | 6,889,764 | 14,359,473 | 18,931,699 | 26,344,733 |
| Mid-price | 2.9 | 34,271,655 | 63,196,933 | 80,419,255 | 99,233,382 |
| Economy | 2.6 | 12,588,520 | 23,213,230 | 28,816,253 | 32,284,084 |
| Total or average (weighted) | 2.9 | 53,749,939 | 100,769,636 | 128,167,208 | 157,862,199 |
| **% change** | **4.5%** | **-2.7%** | **2.4%** | **2.3%** | **1.7%** |

**Note:** Market value is calculated by multiplying the quantity of cigarettes sold by the average price per segment. Calculation of excise revenues is explained in the Methodology section in the Appendix.

## Scenario II

The sensitivity analysis applies the use of one more scenario with different elasticity assumptions to confirm the consistency of results to the same baseline in 2023 (simplified simulation version). The same pattern is evident in both scenarios–a higher increase in excise taxes generates higher revenues, while tobacco consumption is reduced. The changes are briefly summarized in Table 6a.

**Table 6a.** Excise tax changes impact on government revenues (%), simulation results, Scenario II

| Year | Price/pack | Number of packs | Excise revenue | Excise + VAT revenue | Market value |
|---|---|---|---|---|---|
| 2024 | 4.8% | -3.0% | 2.5% | 2.3% | 1.7% |
| 2025 | 4.5% | -2.8% | 2.3% | 2.2% | 1.6% |

### SHIFTING OF BRANDS BETWEEN ALL MARKET TIERS

Considering the cross-price effects between all market segments, the analysis provides approximately the same results in regard to changes in price, consumption, and revenues (both scenarios) as when these effects are not taken into account (Table 7).

**Table 7.** Excise tax change impacts on government revenues (%) – cross-price effects between all market tiers

| | Year | Price/pack | Number of packs | Excise revenue | Excise + VAT revenue | Market value |
|---|---|---|---|---|---|---|
| **SCENARIO I** | 2024 | 4.9% | -2.8% | 2.7% | 2.6% | 2.0% |
| | 2025 | 4.5% | -2.6% | 2.6% | 2.4% | 1.8% |
| **SCENARIO II** | 2024 | 4.9% | -2.9% | 2.6% | 2.4% | 1.8% |
| | 2025 | 4.5% | -2.7% | 2.4% | 2.3% | 1.7% |

### IMPACT OF PRICE CHANGE ON PUBLIC HEALTH BENEFITS

Using the assumptions and input data for measuring the impact of tobacco price changes on public health benefits, the results of the simulation show that reduced prevalence would lead to an increased number of smokers who avoid premature death. For instance, in the first scenario 3,956 smokers would quit due to the price increase and smoking prevalence would decrease (Table 8). It is assumed that 40 percent, or 1,582 of them, could die prematurely from diseases caused by smoking in the case of no price increase. With the tax changes, 70 percent of those who quit smoking would survive, meaning that 1,108 premature deaths would be averted. The positive effects are also visible in the second scenario, wherein–due to the price increase of 4.5 percent–1,037 lives would be saved.

**Table 8.** Effects of excise tax increase on number of avoided premature deaths – adults

| | SCENARIO I | SCENARIO II |
|---|---|---|
| **Price increase** | **4.8%** | **4.5%** |
| Population (ages 15+) | 506,880 | 506,880 |
| Prevalence of smoking | 31.0% | 31.0% |
| Percent of smokers who would die prematurely from diseases caused by smoking | 40% | 40% |
| Reduced risk from cessation | 70% | 70% |
| Adult smokers | 157,133 | 157,133 |
| Adult smoking deaths | 62,853 | 62,853 |

| | | |
|---|---|---|
| Reduction in adult smoking prevalence | -2.5% | -2.4% |
| Fewer adult smokers | 3,956 | 3,705 |
| New adult smokers | 153,176 | 153,427 |
| Fewer adult deaths | 1,108 | 1,037 |
| New adult deaths | 61,745 | 61,816 |

The effect of an excise tax increase on the number of lives saved can also be estimated for the youth population, applying the same percentage change of price increases from the previous simulations. The number of youth smokers who avoid premature deaths are calculated using the number of the youth population (ages 0–14) and adult prevalence. The procedure is the same as in the case of the adult population, with the only difference that this calculation does not include the percentage of those who would survive if they quit because these are not considered quitters, but instead youth deterred from initiation. Using the adult prevalence, the estimated number of potential future smokers is 34,349.

In the case of a price increase and consequent prevalence reduction, a certain number of youth would then be deterred from starting smoking. Table 9 shows that if the price increases by 4.8 percent, 1,730 future youth smokers would be deterred from starting. In the case of no tax change, 40 percent, or 692 of them, could die prematurely from diseases caused by smoking. On the other hand, with the tax reform, these deaths would be averted among current youth because they would not start smoking.

**Table 9.** Impact effects of excise tax increase on number of avoided premature deaths – youth

| | SCENARIO I | SCENARIO II |
|---|---|---|
| **Price increase** | **4.8%** | **4.5%** |
| Population (ages 0–14) | 110,803 | 110,803 |
| Prevalence of smoking | 31.0% | 31.0% |
| Percent of smokers who would die prematurely from disease caused by smoking (DP) | 40% | 40% |
| Future smokers | 34,349 | 34,349 |
| Youth smoking deaths | 13,740 | 13,740 |
| Reduction in youth smoking prevalence | -5.0% | -4.7% |
| Fewer youth smokers | 1,730 | 1,620 |
| New youth smokers | 32,619 | 32,729 |
| Fewer youth deaths | 692 | 648 |
| New youth deaths | 13,048 | 13,092 |

Even slight increases in taxes can lead to substantial benefits in the context of public health, saving on average between 648 and 692 youth lives, depending on the price increase applied. To conclude, significant tax reforms could save, in total, between 1,685 and 1,800 adult and youth lives in Montenegro. It is also worth noting that estimating lives saved is an underestimate of the positive effects of a tobacco tax increase because it does not account for the improved health of the population or the productivity gains from this far healthier population.

## KEY MESSAGES AND RECOMMENDATIONS

- Raising the specific excise tax on tobacco to the level of 51 euros per 1,000 cigarettes would lead to an increase in:
  - The number of smokers who avoid premature death caused by smoking-related diseases. Specifically, 1,037 adult (smokers who quit) and 648 youth (who would never initiate) lives could be saved.
  - Public revenues of 2.4 percent on average. In other words, more efficient tobacco taxation policy will BOTH significantly reduce tobacco use and generate higher government revenues, benefitting the government.
- Addressing youth smoking is vital because the high youth prevalence in Montenegro and smoking initiation at an early age leads to a higher probability of individuals becoming longtime or lifelong smokers and dying prematurely from smoking-related diseases.
- Compared to many European countries, cigarette prices in Montenegro are still very low across all market segments, ranging from 2.3 euros (economy tier) to 3.4 euros (premium tier). Consequently, there is a problem with high affordability of these products among all population groups.

The Government of Montenegro should be more proactive in relation to tobacco taxation and tobacco control policies including:

- increasing the specific excise tax at least to the level of 51 euros per 1,000 cigarettes earlier than planned, or by mid-2023;
- implementing all complementary non-price tobacco control measures (smoke-free places, standardized packaging, marketing and age restrictions, etc.) more effectively;
- including all existing non-combustible tobacco products such as e-cigarettes and heated tobacco products in taxation and other tobacco control interventions, because of ongoing aggressive industry marketing, high affordability, and increased use by youth;
- incorporating strong anti-tobacco messaging into routine health service provision and routine monitoring of tobacco use and offers of cessation help to all tobacco users;
- raising awareness among all population groups through comprehensive public campaigns on the health risks of tobacco use; and
- incorporating strong anti-tobacco messaging into school curriculum.

# APPENDIX

## METHODOLOGY

### A. Modeling the impact of price changes on revenues

Using the aforementioned data on price, consumption of tobacco products, excise tax, and ad valorem tax, the model simulates changes in government revenues caused by excise tax increases.

It is assumed that the initial retail or weighted average price of tobacco products ($P_0$) is constructed as the sum of excise duties ($ET_0$), value-added tax ($VAT_0$), and net of tax ($NOT_0$), where $VAT_0$ is calculated as a given percentage $\tau$ of the retail price. It thus follows that the selling price is obtained based on the following formula:

$$P_0 = NOT_0 + ET_0 + VAT_0$$

Excise taxes consist of two parts, namely a specific excise tax ($SET_0$), which represents a fixed amount per individual package of tobacco product, and an ad valorem tax, which is a percentage of the retail price of an individual package of tobacco product.

Thus, the amount for the net of tax is obtained in the following way:

$$NOT_0 = P_0 - SET_0 - AV_0 - VAT_0$$

In other words, the net of tax corresponds to the income of the tobacco industry and is measured as the difference between the retail price and all calculated taxes.

Since the consumption of tobacco products $(Q_0)$ for the base year is known, it is possible to calculate the total sales or market value ($TMV_0$) and the total revenue from taxes ($TR_0$) for all three market segments, as follows:

$$TMV_0 = P_0 \cdot Q_0$$

$$TR_0 = (SET_0 + AV_0 + VAT_0) \cdot Q_0$$

By applying changes in tax policies, the new price ($P_1$) is determined according to the formulas:

$$P_1 = \frac{\frac{(1 + VAT_1) \cdot (NOT_1 + SET_1)}{1 - AV_1}}{1 - \frac{AV_1 \cdot VAT_1}{1 - AV_1}}$$

Where $SET_1$, $AV_1$, $VAT_1$, and $NOT_1$ represent the new values that are increased by a defined percentage in simulation assumptions.

By determining the price ratio in the previous and current years, it is possible to calculate the percentage change ($PI$) in the price of a tobacco product:

$$PI = \frac{P_1 - P_0}{P_0} \cdot 100\%$$

As an input parameter in the model, it is necessary to know the price elasticity ($E_p$), cross price elasticities ($E_{cp}$), and income elasticities ($E_i$) for the three market segments. Calculation of the new number of packs will be different for premium, mid-price, and economy market segments.

Therefore, the new amount of consumption in year $n$ for a premium market segment ($Q_1^{pr}$) can be obtained by the following formula:

$$Q_1^{pr} = Q_0^{pr}\left(1 + E_p^{pr}\left(\frac{P_1 - P_0}{P_0}\right)\right) \cdot (1 + GDP \cdot E_i^{pr}) - (E_{cp}^{pr} \cdot Q_0^{pr})$$

Where $E_p^{pr}$ represents the price elasticity for the premium segment of the base year, $Q_0^{pr}$ represents the consumption of the premium market of the base year, $E_i^{pr}$ represents the income elasticity for the premium segment, and GDP is an estimated GDP growth rate.

The new amount of consumption in year $n$ for the mid-price market segment ($Q_1^m$) can be obtained by the following formula:

$$Q_1^m = Q_0^m\left(1 + E_p^m\left(\frac{P_1 - P_0}{P_0}\right)\right) \cdot (1 + GDP \cdot E_i^m) + (E_{cp}^{pr} \cdot Q_0^{pr}) - (E_{cp}^m \cdot Q_0^m)$$

Where $E_p^m$ represents the price elasticity for the mid-price segment of the base year, $Q_0^m$ represents the consumption of the mid-price market of the base year, $E_i^m$ represents the income elasticity for the mid-price segment, GDP is an estimated GDP growth rate, and $E_{cp}^m$ is the cross-price elasticity for the mid-price segment.

The new amount of consumption in year $n$ for the economy market segment ($Q_1^e$) can be obtained by the following formula:

$$Q_1^e = Q_0^e\left(1 + E_p^e\left(\frac{P_1 - P_0}{P_0}\right)\right) \cdot (1 + GDP \cdot E_i^e) + (E_c^m \cdot Q_0^m) - (E_c^e \cdot Q_0^e)$$

Where $E_p^e$ represents the price elasticity for the economy segment of the base year, $Q_0^e$ represents the consumption of the economy market of the base year, $E_i^e$ represents the income elasticity for the economy segment, GDP is an estimated GDP growth rate, and $E_{cp}^e$ is the cross-price elasticity for the economy segment.

After calculating the new price and consumption data–analogous to the initial calculations–the total market value, the total revenue, and the total income from excise taxes can be determined for each observed year as follows:

$$TMV_i = P_i \cdot Q_i, i \in \{0,1,\dots,n\}$$

$$TR_i = (SET_i + AV_i + VAT_i) \cdot Q_i, i \in \{0,1,\dots,n\}$$

$$TER_i = (AV_i + SET_i) \cdot Q_i, i \in \{0,1,\dots,n\}$$

These formulas are applied to three different market segments (premium, midprice, and economy). In addition, these changes are observed in the overall market.

Each simulation value is also observed in terms of percent change compared to the previous year.

## B. Modeling the impact of price changes on public health benefits

Using data on the adult population, in the baseline scenario, the number of smokers is obtained by multiplying smoking prevalence and number of adults (ages 15+). Similarly, using data on the youth population, the number of future smokers is obtained by multiplying the expected smoking prevalence (same as for adults) by the number of youths (ages 0–14). The number of smokers in both cases is multiplied by the percentage of regular smokers who would die prematurely from diseases caused by smoking, to obtain the total number of deaths or SDb.

The simulation starts with the estimation of the reduction in smoking prevalence (%SP) due to the price increase %p:

$$\%SP = \varepsilon_p \times \%p$$

Where $\varepsilon_p$ stands for prevalence elasticity. The number of quitters (Qn) is calculated as:

$$Qn = AS \text{ X } \%SP$$

Where AS refers to the number of adult smokers from the baseline scenario. Therefore, the simulation gives a number of the new adult smokers (ASn):

$$ASn = AS - Qn$$

With the assumption of the percent of adult smokers who would die prematurely from diseases caused by smoking (%DP) and reduced risk from cessation (%RRC), fewer adult smoking-attributable deaths (SDf) are estimated as:

$$SDf = Fn \text{ X } \%DP \text{ X } \%RRC$$

The final number of adult deaths caused by smoking (SDn) is calculated, by subtracting the reduced number of adult smoking-attributable deaths from the total smoking-attributable deaths SDb (baseline scenario).

$$SD_n = SD_b - SD_f$$

The same procedure applies for the youth population. The difference is that, instead of classifying youth as quitters, the analysis considers them future smokers deterred from smoking initiation. Since the analysis accounts for the youth alive today and prevented from smoking and dying, fewer youth deaths are estimated only using the probability of premature death from smoking or %DP.