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Tobacco control and optimal taxation in a changing European market landscape

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Abstract

A widely-supported aim of governments is to reduce the consumption of health-harming tobacco products and to increase their cessation. To reach this goal, the European Union is preparing a revision of its tobacco-related taxation. A crucial question in this revision is how to treat new (non-combustible) products like heated tobacco and e-cigarettes. The taxation of non-combustible products is two-fold: It can contribute to overall cessation since the entire market becomes less attractive or it can prevent traditional smokers from substituting for less harmful products.

This paper provides evidence on European consumers' perceptions of combustible and non-combustible products. First, we assess the reason for substituting for less harmful products. Second, we develop a theoretical framework to determine the optimal tax environment on the tobacco market. Lastly, we survey empirical evidence on US consumers' responses to e-cigarette taxation and their impact on smoking prevalence. In addition, we apply price elasticity estimates from the US to European market data.

Nearly all available data and studies indicate a positive cross-price elasticity, which has significant implications for tax policy. Our policy recommendation encourages price differentials between combustible and non-combustible products such as heated tobacco products and e-cigarettes. Additionally, we argue that smoking prevalence is not a sufficient measure for public health, since consumption of non-combustible alternatives is excluded. As an alternative, a measure for general harm level should be used.

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1. Introduction

EU legislation lays down the harmonised rules for excise duties on tobacco. The Council Directive 2011/64/EU aims to "ensure the proper functioning of the internal market and, at the same time, a high level of health protection" (par. (2)). That is, the EU aims for similar price levels across EU-27 member states to ensure the proper functioning of the internal market and a low smoking prevalence to protect public health. By 2040, the share of tobacco users is targeted to be below 5%, according to *Europe's Beating Cancer Plan* (p. 10).

The effectiveness of the current Directive is questioned, also by the European Commission itself. Therefore, the Directive is currently under review (see Ch. 2). When reviewing the Directive, non-combustible alternatives (henceforth: NCAs) such as e-cigarettes and heated tobacco products (HTP), which are not explicitly covered by the Directive, should be included. Their market share has grown considerably over the last few years, and these products can be expected to gain in importance. The question of how NCAs should be taxed to reach the EU Commission's objectives needs to be evaluated.

Under consideration when regulating and taxing these new products is how much of a threat they are to health. Evidence indicates that NCAs are less harmful than conventional, market-dominating combustible cigarettes. It is commonly accepted that substituting combustible products with NCAs is associated with harm reduction. In Ch. 3, we investigate in detail what is currently known about NCAs and their harmfulness compared to combustibles. We also investigate the reasons why consumers start using NCAs.

The different harmfulness levels of combustible tobacco products and NCAs is only one factor to consider when assessing an appropriate tax environment. Another crucial factor is how different duty prices mutually affect the demand for each product. If smokers do not quit smoking due to price increases, the best subsequent response would be to switch to less harmful products. This switching requires that both products are substitutes rather than complements. Therefore, understanding the interplay is crucial for policy measures (see Ch. 5).

Taking the increasing market share of NCAs into consideration, the question of whether smoking prevalence is a good indicator to measure the protection of public health can be raised. Smoking prevalence only covers the consumption of cigarettes but omits NCAs. Although NCAs are less harmful than combustibles, the consumption of these products is still not risk-free. Excluding the detrimental effects of NCA consumption when analysing public health, using smoking prevalence does not provide the full picture. As an alternative to smoking prevalence, the general harm level due to all combustible products and NCAs could be used. We introduce such a measure in Ch. 4, and we use that comprehensive measure in our simulation scenario in Ch. 5.

This paper provides evidence on European consumers' perception of combustible products and NCAs. We contribute to how the EU Commission should tax non-combustible alternatives. The paper is structured as follows: First, we provide an overview of the current regulatory framework regarding the taxation of tobacco products on the EU-27

level and investigate if the current Directive is contributing successfully to the EU commission's objectives (Ch. 2). Second, we depict what is known about the harmfulness of NCAs and assess the reason for substituting combustibles with less harmful products (Ch. 3). Third, we develop a theoretical framework to determine the optimal tax environment for the tobacco market (Ch. 4). Finally, we survey empirical evidence on US consumers' responses to e-cigarette taxation and their impact on smoking prevalence (Ch. 5). We also apply price elasticity estimates from the US to EU-27 market data.

2. Evaluation of the Council Directive 2011/64/EU

Directive 2011/64/EU determines the structure and excise duty rates applied to manufactured tobacco products in the EU member states. It then levies minimum excise duties on different tobacco products to reach these goals. For example, the tax on cigarettes consists of two components: (1) a specific component of between 7.5% and 76.5% of the total tax burden (TTB)—expressed as a fixed amount per 1,000 cigarettes, and (2) an ad-valorem component—expressed as a percentage of the retail selling price (RSP). Additionally, the excise rate must be at least €90 per 1,000 cigarettes and at least 60% of the weighted average retail selling price (RSP WAP).[1]

Figure 1: *Tobacco excise tax yield in the EU-27 member states, 2019.*

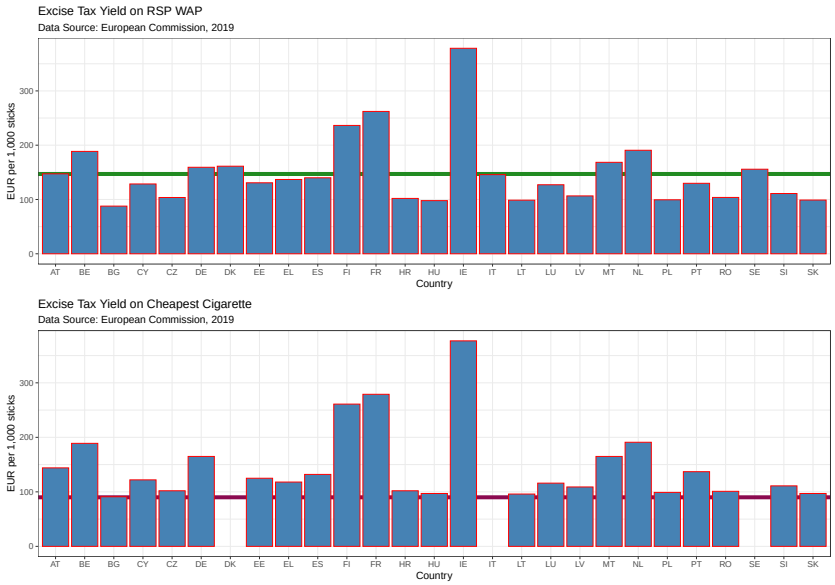


Figure 1 depicts the excise tax yield on 1,000 cigarette sticks for each of the EU-27 member states. Eleven countries lie above the average of around €146 per 1,000

[1] Countries that apply an excise duty of €115 or more do not need to comply with the 60% criteria. Nine member states (Bulgaria, Estonia, Greece, Latvia, Lithuania, Hungary, Poland, and Romania) were granted a transitional period to reach the prescribed EU minima for cigarettes, which expired at the end of 2017.

cigarettes in 2019 (green horizontal line). Large differences between the member states are illustrated (upper figure). While the highest excise tax yields are generated in Ireland, France and Finland, the lowest can be found in Bulgaria, Hungary and Lithuania. For the latter countries, Figure 1 shows that excise tax yields on the cheapest cigarette (lower figure) narrowly fulfil the mandatory minimum of €90 per 1,000 sticks (purple-coloured line).[2]

In addition, the EU commission concludes that the Directive's objective of reducing price differentials between EU member states has not been achieved. Thus, the notable differences in excise tax yields in 2019 seem to translate into price differences. European Commission et al. (2020) even state that the gap between countries with the lowest and highest taxes slightly increased.

Several EU member states have already introduced taxes on e-cigarettes and HTP. These taxes differ not only in the applied structure but also in the tax rates,[3] which jeopardises the Directive's objective to harmonise prices. As a response to the changing market landscape and the critical evaluation of the effectiveness, the EU Directive is currently under review. The crucial question is how to treat NCAs.

It is also questionable whether the Directive's stated objective to protect public health by reducing smoking prevalence has been achieved. Figure 2 depicts the WHO estimates of smoking prevalence for the total population and by gender. Even though the smoking prevalence is decreasing, it remains relatively high among EU-27 member states. Thus, the effectiveness of EU measures is in question. European Commission et al. (2020) conclude that the Directive's contribution to the decline in smoking prevalence was limited to a few countries with low tax levels. Since the target is to reduce the share of tobacco users to below 5% by 2040 (*Europe's Beating Cancer Plan*), the reduction in the smoking prevalence in the EU-27 is certainly not sufficient. Considering the current smoking prevalence is around 25%, this goal seems ambitious as it implies an 80% reduction in roughly 20 years. From 2007 to 2018, Europe's prevalence declined by 10%.

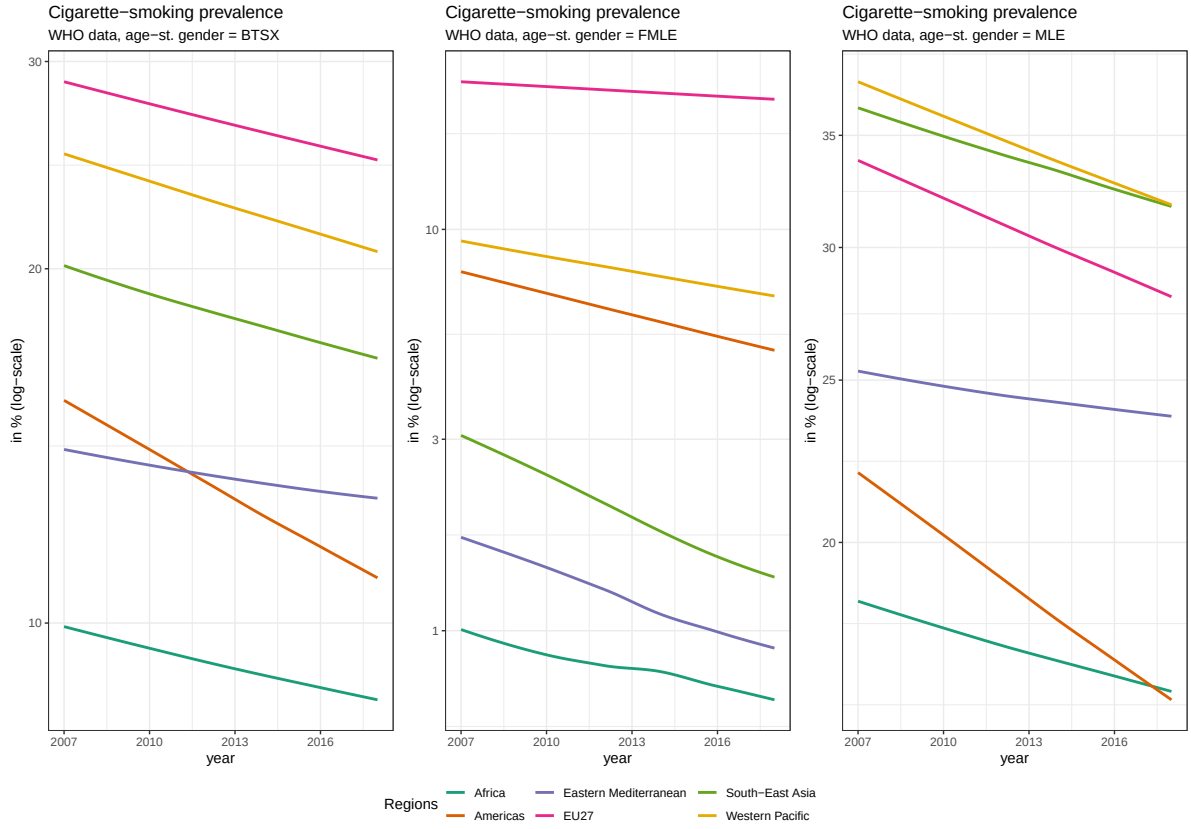
Another interesting observation is the difference in the development of smoking prevalence among females and males. While the prevalence among men significantly decreased and are in line with other regions, smoking prevalence among women is remarkably high in the EU-27 member states. Little progress in reducing this rate can be observed.

Such differences can be seen as a different response to the common regulatory environment, which leads us to question the impact of the chosen policy measures. While these seem to work well for the male population, the same actions seem to have little or no effect on the female population. These gender differences in response to tobacco-policy measures are also addressed by the European Commission (European Commission et al., 2020) and are analysed in recent literature. For example, Ngo et al. (2019) argue that although female smokers are more responsive to an average tax increase, they seem to

[2]The Excise Duty Tables for 2019 published by the European Commission do not contain Denmark, Italy, and Sweden values.

[3]For example, ten countries introduced taxes on HTP by weight and Italy and Hungary tax HTP by the stick. The applied tax rates vary from zero (temporarily in place in Poland and the Czech Republic) to €200 per kg (equivalent) in Italy (European Commission et al. (2020)).

Figure 2: *Prevalence estimates in the EU-27 and in other regions.*



be less responsive to VAT tax increases. For the US, most studies indicate that men are more responsive to cigarette taxes than women. However, this result is disputed (see Stehr (2007) for an overview).[4]

Analysing the applied excise tax yield and the developments of the smoking prevalence in the EU-27 member states indicates that the Directive's contribution to reaching its objectives is limited. Additionally, the changing market landscape contributes to the need to review the current Directive. The latter covers only cigarettes, fine-cut smoking tobacco, cigars and cigarillos, and other smoking tobacco. However, non-combustible alternatives such as e-cigarettes and heated tobacco products (HTP) are not explicitly covered by the Directive. The next chapter will shed some light on what is known about NCAs.

[4]Literature finds gender differences as a response to cigarette taxes and price increases. For example, Chaloupka and Pacula (1999) find that the price elasticity for cigarettes among young men is almost twice as high as among women. Gallet and List (2003) find the demand of men to be more elastic than the demand of women (average price elasticity among men is –0.50, and among women, it is –0.34). Palali and van Ours (2019) report that a price increase inversely affects males' starting rate of smoking.

3. Combustibles and NCAs: substitutes or complements?

Compared to conventional tobacco products like cigarettes, the market for e-cigarettes and HTP is still small. Nevertheless, their market growth indicates that they will continue to play an essential role in the tobacco market.[5] When regulating and taxing these new products, focus should be placed on the different threats they poise to health. Evidence indicates that NCAs are less harmful than combustible cigarettes. The 2018 report of the (National Academies of Sciences, Engineering, and Medicine, 2018, p. 1) summarises that "Laboratory tests of e-cigarette ingredients [...] suggest that e-cigarettes are likely to be far less harmful than combustible tobacco cigarettes". Thus, the National Academies concluded that "if e-cigarette use by adult smokers leads to long-term abstinence from combustible tobacco cigarettes, the benefit to public health could be considerable".

(McNeill et al., 2018, p. 20) in a report commissioned by Public Health England made the following policy advice: "Vaping poses only a small fraction of the risks of smoking and switching completely from smoking to vaping conveys substantial health benefits over continued smoking. Based on current knowledge, stating that vaping is at least 95% less harmful than smoking remains a good way to communicate the large difference in relative risk unambiguously so that more smokers are encouraged to make the switch from smoking to vaping". Although the 95%-number reported by McNeill et al. is questionable,[6] it is commonly accepted that substituting combustible products with NCAs is associated with harm reduction. Allcott and Rafkin (2022) interviewed 137 experts from various disciplines and found that a majority regards the harm levels closer than alleged. Experts state that NCAs are 63% less harmful than combustibles (on average), and not 95%. The substitution relationship between NCAs and cigarettes concerns policymakers, as restricting e-cigarettes may increase demand for much more harmful products like cigarettes.

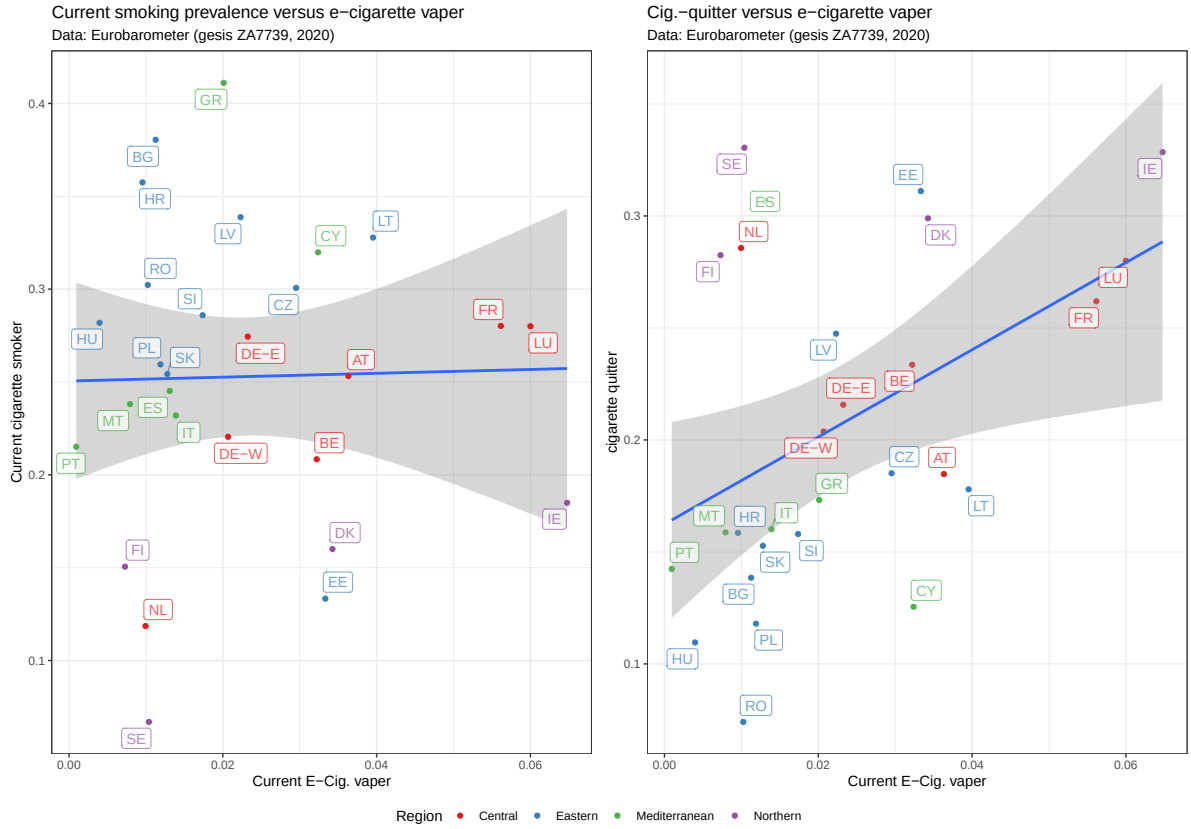
The different harm levels of combustible tobacco products and NCAs are only *one* factor to consider when finding an appropriate tax environment. Another crucial factor is how different duty prices mutually affect the demand for each product. If rising prices do not force some smokers to quit, the subsequent best response would be to switch to less harmful products. This switching requires that both products are substitutes rather than complements. Therefore, understanding of the interplay of these products is crucial for policy measures.

This chapter provides several empirical findings on this interplay using the commonly used data sets of the Eurobarometer surveys for the years 2017 and 2020 (see European Commission (2021a,b)).[7]

Figure 3 shows the relationship between e-cigarette use (vaping) and cigarette smokers' behaviour. The plot on the left-hand side depicts the correlation between cigarette

[5] For example, European Commission et al. (2020) point out that the number of regular e-cigarette users increased from 6 to more than 12 million between 2013 and 2017, and HTP users increased up to 1.3 million between 2016 and 2018. Since 2014, e-cigarettes have been the most commonly used

Figure 3: *Combustible use and vaping behaviour in European countries, 2020.*



smoking prevalence and vaping. The plot on the right shows the correlation between those who quit cigarette smoking and those who vape e-cigarettes. The different label colours indicate EU-27 member states' regional affiliations.

By assessing the data, we found two main insights:

1. The relationship between cigarette smoking prevalence and e-cigarette vaping is ambiguous.

2. By assessing the number of those who quit cigarette smoking with the number of e-cigarette vapers, the correlation is positive. Thus, countries with more quitters are associated with a higher share of e-cigarette vapers.

These findings indicate that EU citizens used e-cigarettes to substitute cigarettes—confirming a widely-ascertained conclusion for the US (see Ch. 5). This suggestion is strongly supported by data reflecting the survey participants' response to which factors

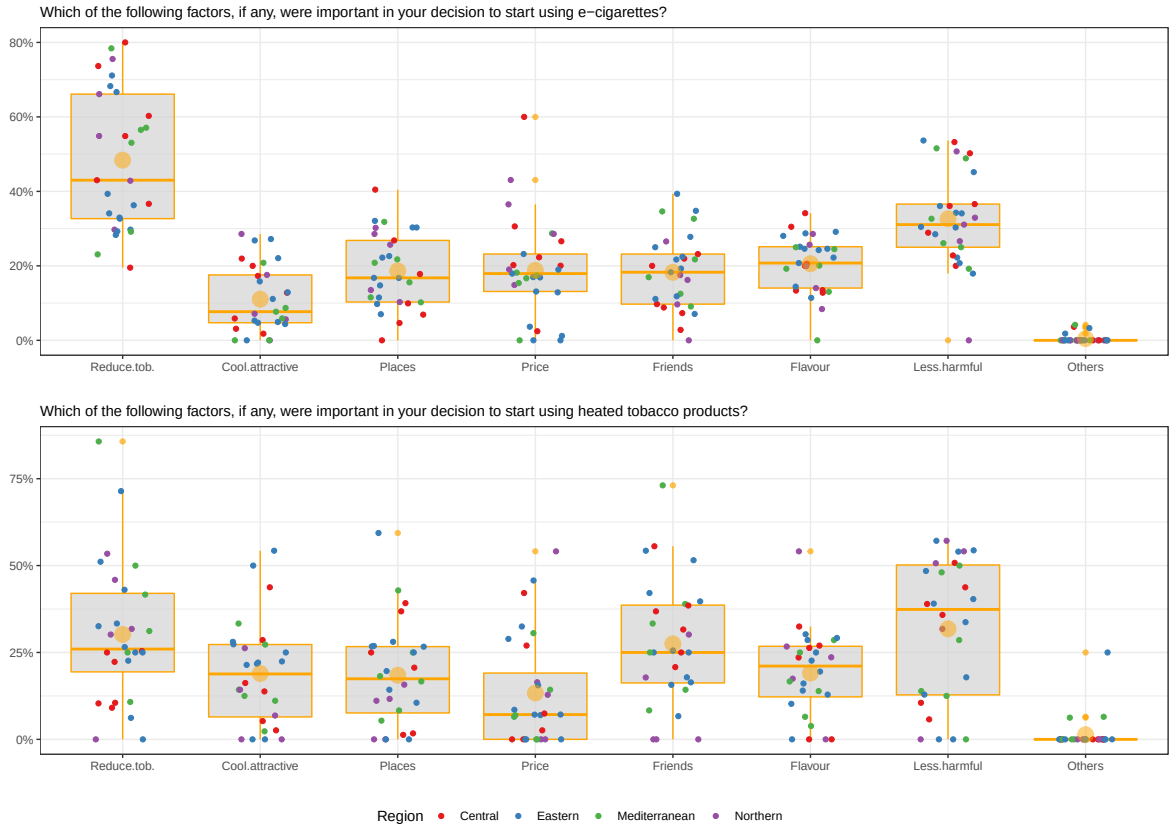
tobacco product among adolescents in the US (Cullen et al., 2019; Gentzke et al., 2019).

[6] citet[p. 223]Glantz2018 questioned the evidence on safety and efficacy of the 95% result.

[7] For example, Eurobarometer data were used by Bogdanovica et al. (2010); Laverty et al. (2021) and others. See Laverty et al. (2021) for a description of the Eurobarometer data.

have been influential in their decision to start using e-cigarettes or HTP. The following reasons were available for selection, and the survey participant's answers are depicted in Figure 4:

Figure 4: *Factors for entry into e-cigarettes and heated-tobacco use.*



Note: The interquartile range (25*th* to 75*th* percentiles) is located within the boxes, such that the median value splits the boxes. The actual (average) value for each country is represented by the points lying on the boxplots. The reasons differ from country to country, and the different colours indicate countries' regional affiliations.

1. To stop or reduce tobacco consumption (short: "Reduce.tob"),
2. They were cool or attractive ("Cool.attractive"),
3. Because e-cigarettes can be vaped in places where tobacco smoking was not allowed ("Places"),
4. Because they were cheaper than tobacco ("Price"),
5. Because of friends using e-cigarettes ("Friends"),
6. Due to the flavours of e-cigarettes ("Flavour"),

7. Because one regarded e-cigarettes less harmful than using tobacco ("Less.Harmful"), and

8. Other reasons ("Others").

The boxplots in Figure 4 display the distribution for each factor for the first use of e-cigarettes (upper plots) and HTPs (lower plot). According to the data, the foremost reason to start using e-cigarettes is to stop or reduce tobacco consumption. On average, around 48% indicate this reason for starting to vape. All other reasons play a comparatively small role. Our results are similar to those reported by Berg et al. (2014) using US data. Strikingly, the picture has fundamentally changed during recent years. In 2014, the most important factors were "Flavour" (39%) and "Price" (38%) (see Stoklosa et al., 2016, p. 1974). Analysing reasons for HTP use shows that, on average, the survey participants' belief that heated tobacco is less harmful than combustibles is the primary reason to start using HTP. Laverty et al. (2021) has recently assessed this entry into HTP use applying Eurobarometer data. Reducing or even stopping cigarette smoking also played a prominent role in first HTP use. Therefore, one can conclude that e-cigarettes and HTP are used as substitutes to combustibles. The next chapter builds the theoretical foundation on how taxation in tobacco markets affect the demand for combustibles and NCAs.

4. Optimal taxation of unhealthy products

Higher taxation is seen as a crucial measure by legal authorities to reduce smoking behaviour (see, e.g., the *Europe's Beating Cancer Plan*). However, taxation affects citizens differently. It is safe to assume that combustible smokers fall into three (not necessarily disjointed) response groups when faced with raising taxes. One group is price-inelastic and will accept paying more for smoking, a second group quits or reduces their consumption, and a third group substitutes combustibles with NCAs. The challenge when revising the Directive is to adjust minimum taxes such that more people fall into the second group at the expense of the first group and without hindering the incentives of the third group.

In general, tax increases lead to tax-induced price increases,[8] and the apparent impact is measured by the own-price elasticity of demand.[9] An increase in cigarette prices usually reduces the demand for cigarettes. For empirical evidence in European countries

[8] In tobacco markets, producers mostly pass tax increases on to consumers. Therefore, tax-rate differentials between products on the tobacco market are expected to translate into price differentials between these products. For example, European Commission et al. (2020) calculate that 0.7 of the tax increase is passed on to prices (EU-27 average). For the US (2013 - 2019), Cotti et al. (2020) find that 91% of e-cigarette taxes are passed on to consumer prices.

[9] A critical effect from tax setting derives from the distributional impact of tobacco taxes. If low-income earners smoke over-proportionally, higher taxes on smoking products can exacerbate more dispersion of disposable income across citizens. For simplicity, we will neglect the distributional effects for the ongoing.

(Spain, Italy), see Fernández et al. (2004); Gallet and List (2003). Besides the effect of tax increases on the product itself, tax increases also affect substitutes and complements of the affected product. The cross-price elasticities measure these effects on related products. The cross-price elasticity indicates how a price change of one product, e.g. cigarettes, affects the demand of other products, e.g. NCAs. Accordingly, many studies analyse cross-price elasticities on tobacco markets, e.g., (Zheng et al., 2016; Huang et al., 2018; Cotti et al., 2020; Allcott and Rafkin, 2022).

The crux of the matter lies in the interplay between own- and cross-price elasticities. Consider increasing taxes on less harmful products. A negative own-price elasticity and increasing taxes make them less attractive, such that their diffusion in the market will be limited. On the other hand, consumers of combustibles might be discouraged to switch to less harmful products if these products are taxed more heavily (positive cross-price elasticity).

Such problems are covered in the economic theory of optimal taxation, which deals with the optimal tax-setting to achieve the highest possible level of welfare, measured by citizens' utility from consuming goods and services. The standard approach in optimal-tax theory maximises welfare by achieving an exogenously set tax revenue. In health policy, the restriction is not to collect a given amount of revenues. Instead, citizens' welfare ought to be maximised by reducing societies' harm to a set level the government targets to achieve.

In the following, we will illustrate how optimal taxation can be modelled in the case of the government's target to reach a set society's harm level, denoted by $\tilde{\mathcal{H}}$. We denote by h_i the harm level associated with tobacco product $i, i \in \{1, \ldots, n\}$.[10] One can think of the harm-level scores provided by, e.g., Nutt et al. (2014) for different products on the tobacco market. Society's harm level is given by

$$\mathcal{H} \equiv \sum_{i=1}^{n} h_i \cdot x_i. \tag{1}$$

The EU targets to protect public health by reducing the smoking prevalence. Using the smoking prevalence as a measure for public health only captures health effects due to consumption of combustibles. It treats switching from combustibles to an e-cigarette as equal to quitting. We argue that $\mathcal{H}$ is a better target than the widely-used smoking prevalence. The main reason is that $\mathcal{H}$ considers that less-harming products *are* harmful nevertheless. Thus, $\mathcal{H}$ seems more appropriate to describe the EU commissions policy goal to protect public health since the harm caused by non-combustible alternatives is also reflected.

The demand for tobacco products depends on prices and how consumers respond to them, such that $x_i = x_i(\vec{p})$, where $\vec{p}$ denotes the price vector. Thus, the demand for a particular tobacco product, x_k ($k \in \{1, \ldots, n\}$) depends on its own price, p_k, and on the other products' prices $p_i, i \in \{1, \ldots, n\} \backslash \{k\}$. The consumer prices comprise the

[10] For simplicity, the term *tobacco product* is used in the following for all combustible tobacco products and their non-combustible alternatives. Note that $\tilde{\mathcal{H}}$ denotes the politically set health level of the society. The actual level is denoted by $\mathcal{H}$.

producer prices ($\vec{q}$) and the respective tax ($\vec{t}$). The government is interested in the price level on the market that leads to a politically set health level $\tilde{\mathcal{H}} < \mathcal{H}$. The latter expression denotes that the targeted harm level is below the current one (hence, the health level after the tax setting is better than in the initial situation).[11]

A government's optimization problem may be formulated in terms of the Lagrangean:

$$\mathscr{L}(\cdot) = V(\vec{p}, e) - \lambda \left[\sum_i h_i \cdot x_i(\vec{p}) - \tilde{\mathcal{H}} \right]. \tag{2}$$

$V(\cdot)$ denotes the indirect utility function which we use in line with existing literature as a measure for welfare. The derivative with respect to the tax rate of a particular tobacco product $k \in \{1, \ldots, n\}$ yields

$$\frac{\partial \mathscr{L}}{\partial t_k} = -\mu \cdot x_k - \lambda \cdot \sum_i h_i \frac{\partial x_i}{\partial p_k} = 0. \tag{3}$$

We make use of *Roy's identity*[12] ($\partial V / \partial t_k = -\mu \cdot x_k$), where μ denotes the marginal utility of income to the consumer. The first-order condition (3) can be rewritten to

$$\sum_{i=1}^{n} h_i \frac{\partial x_i}{\partial p_k} = -\frac{\mu}{\lambda} x_k. \tag{4}$$

The left-hand side of the rearranged first-order condition (4) describes consumers' responsiveness to price changes. In order to make the term more interpretable (and accessible for econometric estimates), we split it into an own-price and a cross-price elasticity. The latter is defined as $\eta_{j,k} = \partial x_j / \partial p_k \cdot p_k / x_j$. The own-price elasticity, on the other hand, yields $\epsilon_j = \partial x_j / \partial p_j \cdot p_j / x_j$. By using the elasticity terms, we can rewrite the first-order condition to

$$\epsilon_k \cdot h_k \cdot x_k + \sum_{i \neq k} \eta_{i,k} \cdot h_i \cdot x_i = -\frac{\mu}{\lambda} x_k \cdot p_k. \tag{5}$$

The first term denotes the harm level of the targeted good, weighted by its own-price elasticity. The second term denotes the summed harm level of all other products, weighted by the sum of their cross-price effects. Dividing both sides of Eq. (5) by x_k / p_k yields—after some straightforward rearrangements—the optimal tax level t_k^* (necessary condition) for product x_k.

$$t_k^* = -\frac{\lambda}{\mu} \left[h_k \cdot \epsilon_k + \sum_{i \neq k} \eta_{i,k} \cdot h_i \frac{x_i}{x_k} \right] - q_k. \tag{6}$$

[11] The assumption $\tilde{H} < \mathcal{H}$ is crucial since otherwise all effects derived in this section would reverse. The reason is that if $\tilde{H} > \mathcal{H}$, then the society would be healthier in the initial situation, and the government would aim to increase society's health hazard.

[12] For an overview on optimal taxation and the properties of the indirect utility function (envelope theorem) see Atkinson and Stiglitz (2015, Ch. 12-2).

To illustrate the implications, let us focus on some exceptional cases of Eq. (6). We do not use exceptional cases to describe the actual policy implications but to deepen the insights on how an optimal tax works in this simple framework. For simplicity, consider only two goods, $\{k, i\}$. One can think of k to represent NCAs and i to represent combustibles.

1. Consider no cross-price elasticity ($\eta_{i,k} = 0$). If the own-price elasticity, ϵ_k, is negative (higher prices imply reduced demand), the optimal tax imposed on product k then depends positively on h_k (thus, the higher the harm level of product k, the higher it should be taxed). The effect of increasing harm levels is amplified with an increasing own-price-elasticity ($\epsilon_k \downarrow$). This follows immediately from $\frac{\partial t_k^*}{\partial h_k} = -\frac{\lambda}{\mu}\epsilon_k > 0$. If the own-price elasticity is positive (a case not reported on tobacco markets to our best knowledge with the exemption of some simulation results by Allcott and Rafkin (2022), see Ch. 5), the taxes shall be negatively correlated with increasing harm level, h_k.

2. If both elasticities are zero, there is no reason to tax NCAs from a health-policy perspective. Here, the distinction to classical optimal-tax theory becomes evident. If the government's restriction is to raise an exogenously set tax revenue, then $\epsilon_k = 0$ implies a high tax rate. The reason is that completely inelastic demands can be taxed without any excess burden caused by substitution effects.

3. Next, consider that only the demand x_k (NCA) is entirely inelastic, $\epsilon_k = 0, \eta_{i,k} > 0$. Imposing or raising the tax for NCA raises the demand for combustibles, which contradicts the government's goal. Consider that combustibles have the largest market share ($x_i/x_k > 1$) and the highest threat to health ($h_i = h_{\max}$), then the optimal tax to NCAs shall be negative. In this extreme hypothetical scenario, rather than increasing the prices of NCAs, they should be negatively taxed (hence, subsidised) to prevent NCA users from smoking cigarettes.

In practice, none of the variables in Eq. (6) can be assumed to be zero. The optimal tax rate for any product results from a thorough consideration of the products' different impacts on health, market share, and elasticities. In particular, if more than two products are on the counter, the optimal tax for any product depends on the sum of the cross-price effects to any other product. The implication for EU policy (and tax policy in the member states) is that tax setting with health goals must consider an entire table of elasticities. While several data exist for the US, the main shortcoming in the European Union is that such elasticity estimates are missing, although they are necessary.

In contrast, the US market is well investigated, and elasticity estimates are available. Hence, we will provide an overview of them in the next chapter and apply them to the EU market—the second-best solution as long as no EU estimates are available. Thus, we show a hypothetical simulation scenario on how cigarette demand would change if e-cigarette prices increased.

5. Recent empirical evidence and some simulation results for EU-27 member states

Recent empirical evidence indicates that e-cigarettes and combustible cigarettes are substitutes.[13] We will briefly survey the most recent studies from the plethora of related studies. They all deal with US data, highlighting the need for further research in Europe.[14]

Minnesota was the first US state to tax e-cigarettes in 2010.[15] Initially, 35% on the wholesale price was taxed; three years later, the tax rate was set to 95%. Saffer et al. (2020) find that the e-cigarette tax in Minnesota led to an increase in adult smoking and reduced smoking cessation. The cross-price elasticity (the elasticity of smoking prevalence regarding e-cigarette prices) is estimated to be 0.13. A 10% increase in e-cigarette prices, thus, is estimated to have increased smoking prevalence by 1.3%. By calibrating Minnesota data on the national US level, they estimate that taxing e-cigarettes at the same rate as combustible cigarettes would deter about a quarter of potential quitters (around 2.75 million (henceforth: m) US citizens) from cessation.

The number of around $2.75m$ potential quitters who could be deterred from stopping smoking resembles an estimate by Pesko et al. (2020). An extra $2.5m$ adult smokers is estimated if an e-cigarette tax of \$1.65 per millilitre (henceforth: ml) of vaping liquid were imposed nationwide. Using survey data from 2011 to 2018, they find that e-cigarette taxes are associated with the increasing use of combustible cigarettes, hence, a positive cross-price elasticity. In particular, they find that a \$1.00 increase in tax (per ml of vaping liquid) increases daily smoking propensity by 5.3%.

By using data on around $94k$ students and their smoking and vaping behaviour from 2011 to 2015, Pesko and Warman (2022) find a strong indication for a substitutive relationship between e-cigarettes and combustibles. Their primary focus lies on the number of cigarettes smoked after an increase in e-cigarettes prices. They estimate that a \$1.00 e-cigarette price increase leads to a monthly rise in cigarette demand between 3.6 and 4.8 daily average cigarette sticks consumed per smoker. Similar to Pesko et al. (2020), they also find higher responsiveness to prices among younger adults.

Finally, we will shed some light on two recent studies with a sizeable methodological overlap. Allcott and Rafkin (2022) argue that the positive cross-price elasticity of cigarette demand on e-cigarette prices vanishes (becomes insignificant) if pre-existing sale trends were considered. Their simulation results on the optimal e-cigarette taxes depend on several parameters. The relative harm level of e-cigarettes compared to combustibles and the actual cross-price elasticities play a crucial role. The latter depends on the specification of the general sale trend. Whereas Allcott and Rafkin (2022) use a much more sophisticated model than we did in the previous chapter, the crucial pa-

[13] Data on cross-price elasticities of HTP price increases on cigarette demand are—to the best of our knowledge—not yet available (as of March 2022).

[14] For differences in the cigarette smoking prevalence, tobacco smoking prevalence and tobacco use prevalence between the US market and selected European markets, see 2 in the Appendix.

[15] As of Mid 2021, 28 US states and Washington DC had passed taxes on e-cigarettes. The different rates and bases are mapped on the site of the tax foundation. See also Abouk et al. (2021).

Table 1: *Survey Table on recent studies - Effect of e-cigarette prices on combustible-cigarette demand*

Source	Obs. period	Focus group	Effect
Pesko and Warman (2022)	2011–2015	Youths	$\$1.00 \uparrow \Longrightarrow [3.8, 4.6]$ c./m.
			100% ad val. $\uparrow \Longrightarrow$ 7.9% $\uparrow$
Allcott and Rafkin (2022)	2011–2017	Overall	ambiguous
Abouk et al. (2021)	2010–2019	Youths	$\eta_{e,c} = +0.34$
Pesko et al. (2020)	2011–2018	Adults	$\$1.00 \uparrow \Longrightarrow$ 5.3% $\uparrow$.
Cotti et al. (2020)	2011–2019	Overall	$\$1.00 \uparrow \Longrightarrow$ 10% $\uparrow$
			$\eta_{e,c} = +0.50$
Saffer et al. (2020)	2010–2015	Adults	$\eta_{e,c} = +0.13$
Abouk et al. (2020)	2013–2017	Pregnants	$\$1.00 \uparrow \Longrightarrow$ 0.04*pp* $\uparrow$

rameters for assessing the optimal tax remain the same. The optimal e-cigarette tax varies from prohibitively high to a negative one (subsidy of e-cigarettes), depending on the elasticity and harm level specifications. It is also possible that smoking and vaping are substitutes for older people but complements for younger consumers (indicating a negative cross-price effect for youths).

The main difference to Allcott and Rafkin (2022) in the paper by Cotti et al. (2020) is that Cotti et al. consider an extended time period. While using the same data source, Allcott and Rafkin (2022) consider the period from 2013 to 2017 and Cotti et al. consider two subsequent years until 2019. Although short, these two years can be crucial because the e-cigarette market expanded substantially after 2017. Moreover, the regulative environment changed substantially: At the end of 2019, seventeen states taxed e-cigarettes. Two years earlier, seven states only imposed taxes on vaping devices.

The differences in results are striking. The cross-price estimate in Cotti et al. (2020) is 0.5. Abouk et al. (2021) find a cross-price elasticity from e-cigarettes to combustibles of 0.34 (US adults, 2010 - 2019).[16] The only halfway recent study for European countries by Stoklosa et al. (2016) also supports this conclusion. The estimate is an own-price elasticity of e-cigarettes of -0.8. Unfortunately, they could not precisely calculate the effect of e-cigarette prices on cigarette demand.[17]

Table 1 roughly summarizes recent studies regarding cross-price elasticity estimates. It can be ascertained that more recent studies found a significant higher cross-impact than the previous examination by Zheng et al. (2016), who found a cross-price elasticity of 0.004 to cigarette demand. The increase in cross-price effects over time is all but surprising. E-cigarettes have become a significant part of tobacco markets in recent years, such that their price level have increased and the quantities of cigarettes have

[16] More studies are surveyed by (Pesko and Warman, 2022, p. 137).

[17] Their conclusion that cigarettes and e-cigarettes are economic substitutes is based on the inverse cross-price elasticity, i. e., from cigarette price on e-cigarette demand (of about 4.6). The authors emphasize that this exceptionally high number is due to the tiny size of the e-cigarette market in the considered years (2011–2014).

decreased.[18]

Virtually all available evidence strongly suggests that e-cigarettes and combustible cigarettes are substitutes. Thus, there is good reason to fear an unwanted increase in cigarette smoking due to a tax increase on e-cigarettes. However, we cannot stress enough that all previous studies use data from the US and recent studies for Europe are not available.

This paper does not fill the data gap. However, we can simulate the effect of a tax increase on e-cigarettes in Europe by adopting some numbers from the US and applying the scarce data we have for the EU-27. In particular, in 2020, around $679b$ (billion) cigarette sticks and fine-cut tobacco sticks (equivalent) were consumed. This compares to a figure of $53b$ e-cigarette stick equivalents.

Let us apply the own-price estimate of -0.8 by Stoklosa et al. (European case) and the lowest cross-price elasticity in recent literature ($\eta_{e,c} = 0.13$) (Saffer et al., 2020). Then, a 1% increase in taxes on e-cigarettes implies

1. a reduction of e-cigarette consumption by $423k$ cigarette sticks equivalent, and
2. an increase of cigarette (factory-made and fine-cut) by $883k$ cigarette sticks.

Applying to these numbers the different harm levels yields the deterioration of European health in the sense outlined above ($\mathcal{H} = \sum_i h_i \cdot x_i$). Assuming the (disputed) harm level of 5% of e-cigarettes compared to combustibles. Thus, we assign (in line with Nutt et al. (2014)) to the cigarettes a harm level of $h_c = 1$ and a value $h_e = 0.05$ to e-cigarettes. The effect on public health then is a deterioration by $861k$ units. However, even by assuming $h_e = 0.37$, the value suggested on average by experts who were interviewed by Allcott and Rafkin (2022), the deterioration would yield still $\Delta\mathcal{H} = 726k$ units.

As mentioned above, the European Commission seems more interested in smoking prevalence. However, a prevalence estimate requires the assumption on who will smoke the additional cigarette sticks: the existing smokers (then, prevalence remains the same), or consumers that use cigarettes because of increasing e-cigarette prices (assuming the e-cigarette prices double, the prevalence increases up to 13% still by applying the above-mentioned conservative estimate). The precise effect can hardly be estimated. However, it will lie between 0% and 13%. In the latter case, the current smoking prevalence could increase from 25% to around 28.3%.[19]

6. Conclusion

We confirm the European Commission's view that a revision of the Tax Directive is needed. However, before the revision written, it is crucial that policy makers understand

[18] Since the cross-price elasticity is $\eta_{e,c} = x_c'(p_e) \cdot \frac{p_e}{x_c}$, both mentioned effects increase the second factor.

[19] Since elasticity estimates are not available for HTP, we cannot rerun the same simulation assuming HTP tax-induced price increases. Assuming that the same logic for e-cigarettes also applies to HTP, the smoking prevalence increase could be even higher if HTP would also be subject to higher taxation.

how different tobacco products interact with each other. We find strong indications that combustibles and NCAs are substitutes. With the generally accepted finding that NCAs are less harmful, a significant tax wedge between combustibles and NCAs is needed for substituting combustibles with NCAs. A well-designed tax on NCAs should be at low rates to encourage switching from combustibles to NCAs and prevent relapsing back to combustibles.

Additionally, we find gender-specific differences in response to tobacco control policies in Europe. It appears the current regulatory measures are only suited to reducing smoking among the male population. Female smokers, on the other hand, do not seem to be affected by the current regulatory environment. It appears extremely unlikely that the European Commission will reach its health-policy goals without the female proportion of the population being as effectively engaged. The remarkable gender differences that we outlined in Figure 2 give reason to invest in research on gender-specific measures.

Our policy recommendations can be underlined by pointing to European Commission's self-declared goals. According to their *Europe's Beating Cancer Plan* (p. 10), the share of tobacco users is targeted to be below 5% by 2040. Considering that current tobacco use hovers around 25%, this goal seems overly ambitious as it implies an 80% reduction in roughly 20 years. From 2007 to 2018, Europe's smoking prevalence declined by 13.4% (-3.94 percentage points), which corresponds to an annual decline of 1.3% (geometric mean). This reduction was achieved by several far-reaching measures. Mandatory smoke-free places, advertisement bans, and the obligation to place graphic pictures on product packaging were all instituted during this time period. Extrapolating the just-mentioned decline rate to 2040, the smoking prevalence would be around 19%. We refer to this scenario as the "Update scenario".

To achieve the 5% target by 2040, the annual decline in smoking prevalence must accelerate to around 7.1% on average ("speed-up scenario"). To achieve this, the European Commission has announced a bundle of new measures (not bolstered by action yet). Even if we suppose that this package is enough to achieve the unprecedented year-on-year decline that is needed, small increases in taxes on NCA's are likely to counteract the favourable impact of the package. Assuming a one-off tax rise such that e-cigarette prices double, two years of prevalence decline in the speed-up scenario would be offset. We illustrate the effect of a one-off e-cigarette tax rise by Figure 5 in the Appendix.

In addition to their 2040 goal, the European Commission announced an interim smoking prevalence target of 20% by 2025, an approximate five percentage points reduction in a short period of time (Europe's cancer beating plan, p. 10). This near-term goal was put into place to follow the WHO's target of a 30% reduction compared to 2010. In 2025, the EU plans revise their package of measures and their tax policy. The EU authorities should invest in additional research to quantify the relevant parameters required for a rational tax and tobacco control policy until then. The UK government has taken a new path. In an attempt to cut smoking rates, e-cigarettes can be prescribed by England's NHS. Manufacturers of e-cigarettes are eligible to apply for approval by UK's Medicines and Healthcare products Regulatory Agency. Whether this approach will be more successful than the EU's measures remains to be seen.

Furthermore, since the widely used concept of smoking prevalence is blind to the

difference between quitting and switching, a broader concept for public health should be considered. We provided a simple example of such a measure.

Our paper shows that most of the available data only deals with the US market; the European market suffers from a general lack of evidence. This assessment is sobering since more data, and hence more research, is needed to better understand the relationship between NCAs and combustibles, otherwise effective tobacco control policies are unlikely to be found.

Overall, the EU strategy lacks research as a decision-making tool. The significant differences in data and research availability compared to the US give no cause for satisfaction but a call to action.

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A. WHO prevalence estimates

Table 2: *WHO prevalence estimates (2018) for the US and selected European countries*

Country	Cig. smoking	Tob. smoking	Tob. use
USA	17.1	20.0	25.1
DEU	26.0	28.0	28.0
FRA	31.5	34.6	34.6
ITA	23.4	23.4	22.8
ESP	25.9	27.9	27.9
POL	24.3	26.0	26.0
SWE	16.9	28.8	12.4
PRT	24.8	27.9	27.9
HRV	33.1	36.6	36.6

B. Simulation of smoking-prevalence development in EU-27

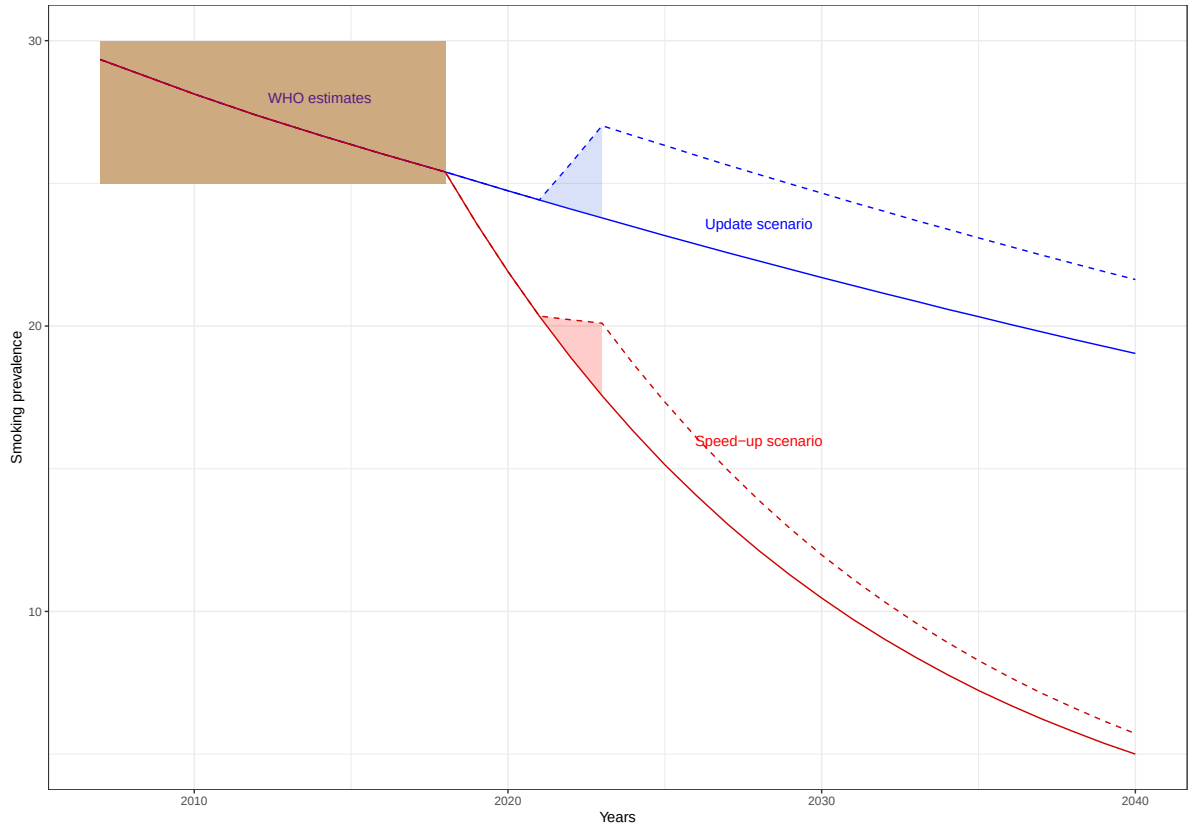

Figure 5: *Smoking-prevalence scenarios.*

The prevalence estimates surrounded by the rectangle are the WHO data. If the prevalence would decrease with the same rate in the future as in the previous decade ("update scenario"), the blue solid line depicts the prevalence prospect. A one-off tax increase on e-cigarettes that lead to doubling the price to consumers yields an increasing smoking prevalence by 13% according to the above-mentioned conservative estimate. We suppose that the effect takes two years to achieve the full impact. The resulting smoking prevalence is represented by the blue dashed line.

In a second scenario, we depict the prevalence development required to achieve EU Commission's target of 5% by 2040 (red solid line, "speed-up scenario"). This target is not bolstered by action yet. However, even in this "speed-up scenario" an one-time tax raise on e-cigarettes would significantly run at cross purposes to policy goals, indicated by the red dashed line.