Estimation of Price and Income Elasticity of Demand for Tobacco Cigarettes in Slovakia

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Abstract

Background

The importance of the behavioral impacts of tobacco taxation in Slovakia has thus far been widely overlooked. The purpose of this study is to utilize available data on household consumption and provide evidence about the elasticities of tobacco consumption in Slovakia at the household level.

Methodology

To estimate price and income elasticity of demand for tobacco cigarettes in Slovakia two approaches namely a two-part model (2PM) and Quadratic Almost-Ideal Demand System (QUAIDS) were employed. The 2PM approach distinguish between household's decision to smoke (which is determined independently) and household's decision regarding the quantity of cigarettes consumed. QUAIDS model estimate total own-price and budget elasticities of cigarette consumption. Utilization of 2PM and the QUAIDS allowed for computing alternative estimates and, thus, provided insight into the potential effect of the choice of method applied on the obtained results.

Results

Estimated total price elasticity of cigarette demand in Slovakia based on the 2PM approach is -1.006 and, according to the QUAIDS estimates, -1.195. Put differently, a one-percent increase in cigarette prices would result in a decrease in overall cigarette consumption from -1.006-percent to -1.195-percent, depending on the model approach. For the expenditure elasticity total elasticities are estimated at 0.844 and 0.970, based on the 2PM and the QUAIDS, respectively.

Conclusions

The estimated levels of elasticities from this study indicate that households are relatively highly responsive to changes in the prices of cigarettes. However, this responsiveness is significantly offset by comparably high total expenditure elasticity, which—in combination with relatively swift increases in household expenses in recent years—resulted in a higher affordability of cigarettes in Slovakia.

By simulating the recent policy change of increasing the specific excise tax rate to EUR 84.60 per 1000 cigarettes, this study finds that this amendment—in light of an expected high increase in household expenditures—would most likely not provide the desired effect of reduced tobacco consumption. In this environment of high household expenditure growth, setting the specific rate at a level of EUR 87 per 1000 cigarettes would be sufficient to guarantee that households' cigarette consumption would not

increase in 2023. Otherwise, the rate following the current policy change is expected to result in a slight increase in cigarette consumption and may have negative impacts on public health and increase associated social and economic costs.

The relatively high price elasticity of manufactured cigarettes can be partially explained by the significant market share of alternative products such as e-cigarettes, heated tobacco products, and nicotine pouches.

JEL Codes: D12, C31, L66
Keywords: cigarette demand, price and income elasticities, policy simulation

Introduction

The importance of the behavioral impacts of tobacco taxation in Slovakia has thus far been widely overlooked. The purpose of this study is to utilize available data on household consumption and provide evidence about the elasticities of tobacco consumption in Slovakia at the household level.

In the year 2020, the Slovak Parliament approved Act No. 390/2020 Coll. increasing the level of tobacco taxes in Slovakia. This resulted in an increase in tobacco taxes for three consecutive years: 2021, 2022, and 2023. Additionally, the specific tax per 1000 cigarettes increased from its initial level of EUR 64.10 to EUR 74.60 in 2021, EUR 79.60 in 2022, and EUR 84.60 in February 2023. In the explanatory report to the Act No. 390/2020 Coll. proposal, the Ministry of Finance expected an increase in tobacco-based revenues of EUR 102 million for year 2021. According to Antalicová (2022), change in revenue collection between 2020 and 2021 was even higher by EUR 21 million. The Ministry attributes this difference to the unexpected delay in payment for taxes due in December 2020.

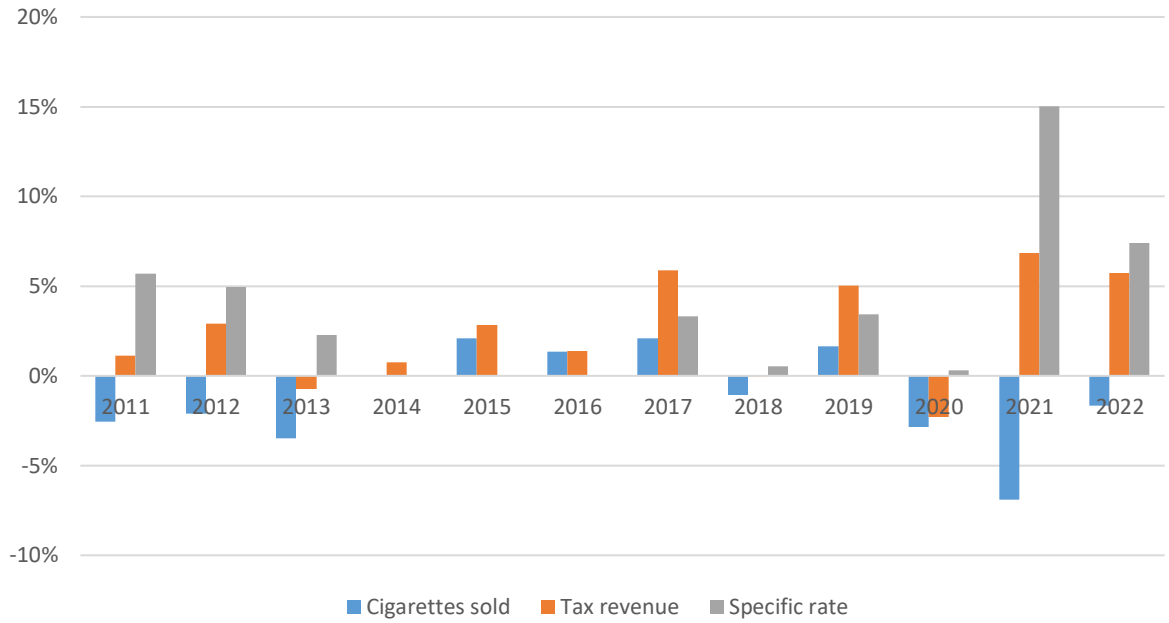
In the period from 2011 to 2022, the tax revenue from tobacco products decreased in only two years: 2013 and 2020. However, changes in those years have different underlying explanations. In 2020, the COVID-19 measures decreased demand, while in 2013, the reduced tax revenue was likely a result of the major economic downturn (

Figure *1*). The specific excise rate increased only slightly between the years 2014 and 2020. As discussed above, the increase in the specific rate by almost EUR 10 in 2021 resulted in a swift decrease of cigarettes sold, which was accompanied by an increase in tax revenues.

The forecasted tax revenue[1] from tobacco products in 2023 should increase by EUR 31 million compared to its level in 2022. According to Ministry of Finance forecast assumptions, the annual change in consumption of cigarettes is expected to decrease by seven percent. It will be partially replaced by increased demand for smokeless tobacco products (21-percent increase) and fine-cut tobacco (six-percent increase).

[1] 73rd meeting of the Committee on Fiscal Forecasts September 2023 - https://www.mfsr.sk/sk/financie/institut-financnej-politiky/ekonomicke-prognozy/danove-prognozy/73-zasadnutie-vyboru-danove-prognozy-september-2023.html

Figure 1. Annual changes (%) in cigarette consumption, excise tax on cigarette revenue, and specific rate per 1000 cigarettes



Source: Ministry of Finance of Slovak Republic

Additional estimates of tobacco demand elasticity might also contribute to this understanding. Therefore, the aim of the presented research is to provide estimates of price and income/expenditure elasticities of tobacco demand in Slovakia, utilizing household-level data on final consumption expenditures. Additionally, obtained elasticities are used in a simulation of the effects of a tax increase on cigarette consumption and tax revenues to provide an estimate of the budgetary impact of the recent change in excise duty levels effective from February 2023.

Literature review

Only a handful of studies have focused on price and income demand elasticities estimation in the context of the Slovak Republic. The majority of the papers dealing with the estimation of elasticities in Slovakia focus on food products (for example, Hupková et al., 2009; Benda Prokeinova & Hanova, 2016; Hupková, 2016; Cupák et al., 2015; Cupák & Tóth, 2017). Some studies also focus on the estimation of household food expenditures by income groups (for example, Kubicová et al., 2011; Rizov et al., 2014).

There has been some local research investigating the development of cigarette and/or tobacco product elasticity. Analysis by König and Dovaľová (2016) used the

QUAIDS model to produce elasticity estimates for broader groups of consumer goods including alcoholic beverages and tobacco. Elasticities, which partially reflect Slovakia as a member of a panel of selected countries of the world, are also available. Specifically, Gallus et al. (2006) estimated cigarette price elasticities for 52 countries within or in the vicinity of Europe, using the double-log multiple linear regression. Results of this research indicate that around the year 2000, "in Europe smoking consumption decreases 5–7 percent for a 10-percent increase in the real price of cigarettes" (Gallus et al., 2006, p.114). There also is a tangential analysis including Slovakia in a panel of countries by Schaap et al. (2008), who estimated the extensive margin in a form of smoking cessation as a reaction on various tobacco control policies. They found that quit ratios[2] for Slovakia, partially affected by nationwide tobacco control policies, were on average 42.5 percent for men and 49.4 percent for women, which can be considered within a high range (greater than 45 percent). For both genders, higher education was associated with a higher quit ratio.

The work of Zimmermannová and Široký (2016) analyzed the economic impacts of cigarette taxation in the Czech Republic and Slovakia in the period 2004–2016. The authors did not estimate elasticity itself and only indirectly concluded that price and income elasticity is low, on the basis of observed public budget revenues' increase accompanying the increase in the tax rates. Also, the analysis of Geško (2017, p.157) indirectly assumed low elasticity of tobacco products "based on the increase in tobacco tax rates, subsequent increase of tobacco products prices and tax revenues." In his analysis, the author pointed out that due to the addictive nature of smoking, quitting is the very last option considered by smokers. Similarly, the analysis of Remitera and Výškrabka (2016) does not provide an exact estimate of the elasticity of tobacco products' consumption. Therefore, based on analysis which did not include the precise estimates of elasticities, the authors concluded that tobacco demand is rather unresponsive to the historical long-term increase in prices. These results could be biased (since there is no precise elasticity estimate), however, as consumers are expected to adjust quickly even to small price increases.

In the conference paper of Jamrich and Pokrivčák (2018), the authors utilized Slovak Household Budget Survey (HBS) data for the period 2006–2012 to estimate the price elasticity of demand for cigarettes. The results indicated that households with light cigarette consumption tend to decrease their consumption more than moderate and heavy smokers. Authors also estimated an "overall elasticity of Slovak households, which was -0.92" (Jamrich & Pokrivčák, 2018, p. 2448) using the Heckman sample-selection model.

[2] Calculated as total former-smokers divided by total ever-smokers.

Concerning the cigarette price elasticity of neighboring countries or countries with similar backgrounds as Slovakia, Verguet et al. (2021) quantified the regressivity of cigarette taxation in five selected countries, which include Bulgaria as a representative of an upper middle-income country, based on price elasticity of aggregate cigarette demand ranging between -1.33 to -0.52, which were obtained from other studies. Ross et al. (2012) estimated the price elasticity of filtered cigarette consumption for Ukraine using both linear regression and the Engel-Granger approach, leading to an elasticity of -0.28. Furthermore, Szilágyi (2007) provided descriptive statistics supporting the notion of a positive effect of cigarette taxation on the general health of the Hungarian population. The study also states "that the price elasticity of tobacco products in Hungary can be put between –0.44 and –0.37" (Szilágyi, 2007, p. 125). Similarly, Prekazi (2018) estimated the conditional own-price elasticity of cigarette consumption in Kosovo to be at the level of -0.288. Meanwhile, Gligorić et al. (2020) found a price elasticity of total cigarette consumption (that is, purchases made on both illicit and official markets) in Bosnia and Herzegovina of −1.366.

Regarding the estimation of analogous elasticities geographically further from Slovakia, Dare et al. (2021) estimated the price elasticity of cigarette demand in the Republic of South Africa, using the Deaton approach, to the response level of -8.6 percent in demand to a 10-percent increase in price. Chelwa and van Walbeek (2019, p. 1) analyzed the price elasticity of tobacco products in Uganda "with elasticity estimates ranging between −0.26 and −0.33," while in the case of India (John, 2008), these estimates range from -0.4 to -0.9.

Although there are a limited number of examples attempting to estimate cigarette consumption price elasticities for Slovakia, reports distinguishing between smoking prevalence and smoking intensity (John et al., 2023) appear to be even more lacking in the context of the Slovak Republic. Within this framework, it is our focus to separately estimate the smoking prevalence price elasticity (that is, the price elasticity of cigarette consumption at the extensive margin) and smoking intensity price elasticity (that is, the price elasticity of cigarette consumption at the intensive margin).

The history of application of this framework begins in the early 1980s; a rather exhaustive overview of which is provided by Chaloupka and Warner (1999). Based on this account, the distinction between smoking prevalence and smoking intensity was already made at the forefront of using individual-level data for examination of tobacco demand by Lewit et al. (1981). Most subsequent analyses followed suit, and this approach became a standard for studies that did not rely on aggregated data (Tauras, 2004). Other examples employing the two-part approach in the context of tobacco or cigarette demand are by Aljinović Barać et al. (2021), Austria and Pugadan (2019), Cheng and Estrada (2020), Cizmovic et al. (2022), Filby (2022), Filby and van Walbeek (2022), Gligorić et al.

(2022), Homaie Rad et al. (2020), Kostova et al. (2011, 2014), Nikaj and Chaloupka (2014), Ross and Chaloupka (2003), Tauras (2004; 2005), Vladisavljević et al. (2021), and Wang et al. (2021).[3]

In some cases, the price elasticity of cigarette consumption at the extensive margin was estimated by itself (for example, Joseph & Chaloupka, 2014; Zare & Zheng, 2021). Similarly, the observations of individuals not consuming cigarettes are usually omitted from the analysis for purposes of certain approaches (such as the original Deaton approach and the QUAIDS model). These studies, therefore, in most cases provide only intensity elasticities of tobacco demand. Other examples of studies providing only price elasticities conditional on the individual being a smoker include Chelwa and van Walbeek (2019), Dare et al. (2021), Gallus et al. (2006), Gligorić et al. (2020), Jamrich and Pokrivčák (2018), and John (2008).[4]

Additionally, most of the tobacco demand analyses featured income as one of the key determinants of tobacco consumption. Due to the outcomes of such early studies, cigarettes were reclassified from a normal good to an inferior good based on obtained magnitudes of income elasticities (Chaloupka & Warner, 1999). Other examples of studies featuring income elasticities of tobacco demand include Austria and Pugadan (2019), Homaie Rad et al. (2020), and Jones (1989). Family income was already controlled for in the seminal work of Lewit et al. (1981). However, the authors do not provide an estimate of income elasticity of tobacco consumption.

Data and Methodology

The section presents the data used for the analysis, lists their sources, and summarizes the limitations imposed on the methodology resulting from the data availability. Subsequently, the methods applied are briefly described in a separate subsection.

Data

The primary source of the data used was the 2020 Slovak Household Budget Survey (HBS), which was provided by the Statistical Office of the Slovak Republic (SOSR). The survey contains 4,633 observations of households, which, according to the reported dates of surveying, were recorded over the extended period between December 2018 and November 2021, and published as a single wave of 2020 Slovak HBS (despite

[3] Wang et al. (2021) further expanded the two-part model by an additional equation, which distinguished occasional smokers from daily smokers.
[4] However, John (2008) also computed unconditional elasticities which are available from the author upon request.

the mismatch of the title and the content).[5] Past rounds of Slovak HBS were also available. However, these were not used due to missing key variables such as the information on primary sampling units (2015 Slovak HBS wave) or the consumed quantities of food, beverages, and tobacco products reported by households (2004–2012 Slovak HBS waves). For other categories of products, consumed quantities were unavailable, even for the 2020 Slovak HBS, which featured consumed quantities of food, beverages, and tobacco products.

Regarding additional sources of data, country-level records regarding declarations on excise duty on tobacco products, covering the period from January 2004 to December 2022 with monthly frequency, were obtained from the publicly accessible website of the Institute for Financial Policy (IFP) of the Ministry of Finance of the Slovak Republic. The same source was also used for acquiring macroeconomic forecasts for Slovakia. Apart from obtaining instruments for cigarette prices this way (see the Appendix), this source proved valuable with regard to baseline information for conducting policy simulations.

Additionally, country-level monthly data on the Harmonised Index of Consumer Prices (HICP) of cigarettes, most available for the period December 2014–June 2023, were acquired from the Eurostat database.

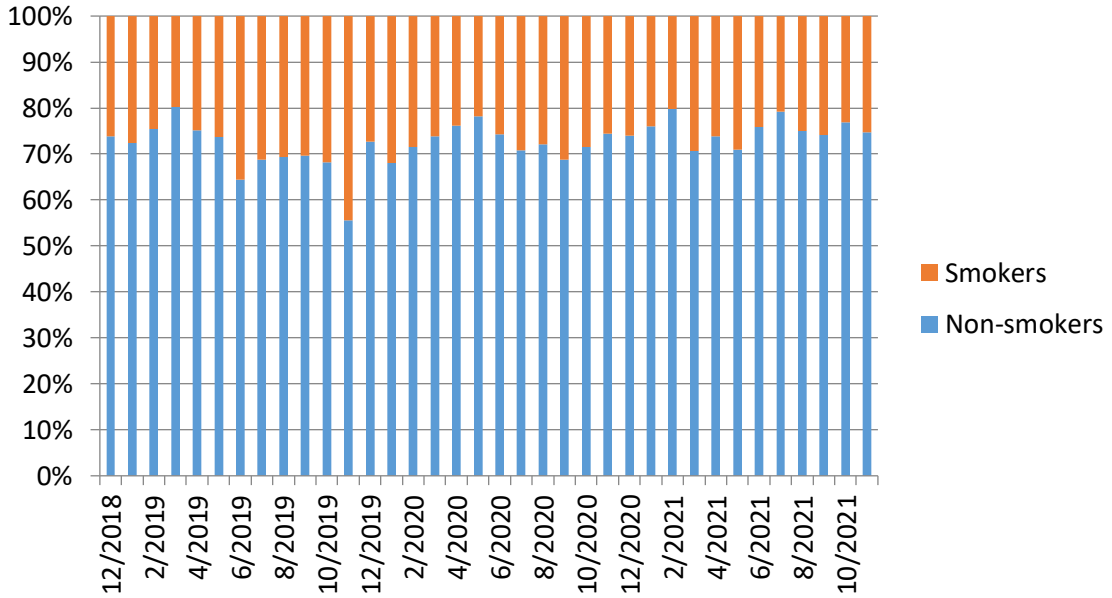
From the 2020 Slovak HBS database, the quantities of consumed cigarettes in the reference period were used as a dependent variable for the second part of the two-part model. The dependent variable for the first part of the two-part model—smoking prevalence (see Figure 2)—was derived from the aforementioned quantities by creating an indicator variable, which takes on a value of 1 when household reported positive consumption of cigarettes and 0 otherwise. The price of cigarettes was proxied by the so-called cigarette unit value, which was computed as total expenditures on cigarettes divided by the consumed quantities at the household level.

The number of 2020 Slovak HBS observations actually used for the analysis was at this point reduced by the exclusion of outliers in cigarette unit values and in total expenditures on cigarettes per household member. In the first step, households reporting cigarette unit values higher than 99.9 percent of the cigarette unit value distribution were omitted from the analyzed sample. In the second step, households reporting total expenditures on cigarettes per household member lower than 0.1 percent of the expenditures distribution or higher than 99.9 percent of the expenditures distribution were excluded from the analysis.

[5] The explanation that was provided by the SOSR states that this approach was followed in order to comply with social distancing measures adopted during the COVID-19 pandemic.

The development of the smoking prevalence calculations based on the Slovak 2020 HBS data presented in Figure 2was relatively stable during the observed period, in most cases ranging between 20–30 percent. This appears to be consistent with the results of Eurobarometer 2020 survey for Slovakia, which indicates smoking prevalence of about 25 percent.

Figure 2. Smoking prevalence



Source: 2020 Slovak Household Budget Survey

The *Updated Toolkit on Using Household Expenditure Surveys for Research in the Economics of Tobacco Control* (John et al., 2023; henceforth referred to as "the Toolkit") suggests using per-period cluster average of cigarette unit values based on primary sampling units as proxies for cigarette prices faced by the individual households. This step should resolve potential issues with endogeneity and quality shading, as well as provide estimates for prices faced by households that are not smoking (John et al., 2023). However, practical implementation of this approach only assigns cigarette prices to roughly half of the available observations for analyzed data, due to a lack of smoking households in some of the clusters. Therefore, a per-period regional average of cigarette unit values were assigned to households for which a corresponding cluster average was unavailable, as recommended by the Toolkit (John et al., 2023). The regional average is the closest geographical aggregate to the primary sampling units available in the 2020

Slovak HBS wave data. The logarithm of the unit value average was, therefore, a key variable of interest in the estimated main specification.

Explanatory variables used as controls in the main specification include a logarithm of total expenditures of households, which are used as a proxy for household income; a logarithm of household size; the average age of members of the household; indicator variables for the employment status of the reference person ("unemployed," "disabled," "student," and "other inactive person," with "employed" serving as a base); an indicator variable for households owning the residence; and an indicator variable obtaining a value of 1 if children (household members with age less than 16 years) are present in the household and a value of 0 otherwise.

Among other explanatory variables considered and examined throughout the analysis—that are, however, only commented upon as part of the robustness—are covariates of total household income; percentile of total household income within the used sample; male-to-female ratio; adult ratio; age of the reference person; overall household employment/economic-activity status (following the methodology used by Cizmovic et al., 2022); education level of the reference person; highest attained level of education within the household; an indicator variable obtaining a value of 1 if the sex of the reference person is female and a value of 0 otherwise; and the full set of regional dummies.

Additionally, detailed data on price development were obtained from the SOSR. The data capture monthly price changes for 157 groups of goods and services according to the COICOP 4-digit classifications for the years 2008–2021. Computed chained price indices from these data were pooled to higher consumption groups as defined in the QUAIDS model specification according to the shares of the subgroups on the given top-level expenditure bundle (for example, ratio of expenditures on cereals to total expenditures on the group of food and beverages).

Methods

The two-part model

For the estimation of elasticities of cigarette consumption, the general approach of the two-part model described in the Toolkit (John et al., 2023) was utilized. However, in Slovak conditions, one of the key assumptions of the Deaton model[6] is violated, since a single price of a pack of cigarettes of the same brand is enforced over the entire territory of Slovakia since 2004.[7]

[6] Deaton (1997), which is the main workhorse of the Toolkit for the estimation of price elasticities on the intensive margin.
[7] Act 106/2004 on Excise Tobacco Duties prohibits that a pack of cigarettes of the same brand would be sold for a different price to the one printed on the protective seal of packaging.

Nevertheless, the general approach recommended by the Toolkit is a two-part model (2PM) in which a household's decision to smoke is determined independently of a household's decision regarding the quantity of cigarettes consumed. Smoking prevalence was in line with the recommendation of the Toolkit estimated using probit regression, assuming the following model (John et al., 2023):

$$Y_i=(y_i>0)=f(\beta_1 p_i+\beta_2 i_i+\Gamma' X_i)$$

where y_i is cigarette consumption of the household *i*. Y_i is an indicator variable taking on a value of 1 if household consumption is positive and a value of 0 otherwise; p_i and i_i are the cigarette price and total household consumption, respectively. X_i represents the vector of additional covariates used in the analysis. The decision on the quantity of cigarettes consumed was estimated using standard ordinary least squares (OLS).

$$y_i=\alpha_1 p_i+\alpha_2 i_i+\Theta' X_i+\varepsilon_i \qquad \text{if } y_i>0$$

The price and income/expenditure elasticities for smoking intensity are identical to the estimated parameters due to the log-log relationship assumed for the smoking intensity equation. Analogous prevalence elasticities were computed as population averages on used samples, based on estimated coefficients and predicted probabilities, while disregarding the potential correlation with the error term. Their standard errors were obtained using the delta method.

Additionally, following the guidelines in the Toolkit (John et al., 2023), the 2PM regressions were tested using the joint statistical significance test (either the F test in the case of the OLS or the likelihood ratio test in case of the probit), specification link test, and Hosmer-Lemeshow goodness-of-fit test, for which ten groups/quantiles were used for the classification of the prediction. Furthermore, for these models the corresponding variant of the coefficient of determination was provided (R^2 in the case of the OLS and McFadden's pseudo R^2 in the case of the ordinary probit) as well as the highest obtained value of the variance inflation factor (VIF).

Quadratic Almost-Ideal Demand System

As an alternative, unconditional demand elasticity might be estimated via the QUAIDS model, which was already used in Slovak conditions, for example, by Cupák et al. (2015), Cupák and Tóth (2017), König and Dovaľova (2016), Lichner and Petríková (2014), and Rizov et al. (2014).

Due to aforementioned challenges with estimating intensity elasticity with the Deaton model and for providing additional robustness check for the above-described 2PM

approach, the QUAIDS model was used to estimate total own-price and budget elasticities of cigarette consumption in Slovakia. The applied approach followed methodological steps by Banks et al. (1997), which incorporates the quadratic Engel curves into the AIDS model proposed by Deaton and Muellbauer (1980).

The QUAIDS model can be specified using an indirect utility function:

$$\ln V^h = \left(\left[\frac{\ln m^h - \ln a\ (\boldsymbol{p}, \boldsymbol{z^h})}{b\ (\boldsymbol{p},\ z^h)} \right]^{-1} + \lambda\ (\boldsymbol{p}, z^h) \right)^{-1}$$

where p is a vector of prices, z^h are household demographic factors, and m^h are the total household expenditures. For further details and underlying assumptions, it is advised to see Banks et al. (1997).

For the estimation of the demand system defined in its quadratic form, the STATA routine by Lecocq and Robin (2015) was used. This QUAIDS implementation builds on the previous work of Poi (2012). The advantages of the applied routine are in its computation time and possibility to control for the endogeneity in income and/or prices commonly associated with demand systems. One of the features of the indirect utility function presented above is its linearity conditional on price aggregators: all equations are linear in all parameters conditional on price aggregators. In the presented application of iterated linear least-squares, the estimator developed by Blundell and Robin (1999) was used.

Additional data limitations in regards to QUAIDS were that the quantities consumed were only available for foods, beverages, and tobacco products. For the remaining categories data are not present. Thus in the model application we built on the works of Dybczak et al. (2014) and König and Dovaľová (2016), who faced similar issues. Those authors used price indices for the consumption groups for which quantities were not available and, on the basis of available unit values, calculated the respective (pseudo-) indexes.

Heckman Sample Selection Approach

Concerning additional validation of the methodology, the approach based on the 2PM outlined above appears to be at odds with the prior analysis of Slovak cigarette demand by Jamrich and Pokrivčak (2018), who assumed that the intensity of smoking is not independent from its prevalence and opted for a Heckman sample selection approach. In order to empirically test the hypothesis of independence of the decisions, the Heckman sample (HS) selection model is estimated in addition to the standard 2PM described above.

The application of the HS approach requires that the selection bias captured through the inverse Mills ratio is identified by variables affecting only the selection equation, but not the quantity equation. In the presented case, this translates into including additional explanatory variables into the first part of the 2PM that are affecting the smoking prevalence, but not the conditional demand for cigarettes or the price. The alcohol drinking prevalence by individual households is one variable that was chosen for such a role, since it was utilized for the same purpose by Jamrich and Pokrivčák (2018). Another variable considered potentially useful in this regard was the level of urbanization, which was used to achieve the same goal by Austria and Pagudan (2019).

From a technical perspective, the HS model was estimated using Roodman's (2008) conditional recursive mixed-process estimator. By the means of this estimator, both parts of the 2PM (the prevalence equation and the intensity equation) are estimated jointly while allowing for potential correlation of the error terms of the two equations. In all models based on joint densities of error terms, the correlation between error pairs was tested using the standard Wald test. This served as a test of endogeneity/sample selection bias.

Simulation of price and excise increase on consumption and government revenue

To further expand on the estimated elasticities, the procedure for performing policy simulations described in the regional study for Albania, Bosnia and Herzegovina, Kosovo, Montenegro, North Macedonia, and Serbia[8] was used to obtain a simple policy simulation that approximates potential responses of cigarette demand and tax revenues to price changes. The elasticities estimated by the 2PM approach and the QUAIDS approach were utilized to determine the new level of demand by applying the following formula:

$$D_{t+1} = D_t * (1 + \xi_p * \Delta p[\%] + \xi_i * \Delta i[\%])$$

where D_{t+1} is the new demand, D_t is the demand in year t, ξ_p and ξ_i are price and income elasticities, while $\Delta p[\%]$ and $\Delta i[\%]$ represent the percentage increases of prices and income.

Results

Prevalence elasticity

Before delving into the economic significance of the results presented in Table 1, the validity of the performed estimation procedures is examined based on obtained test

[8] John et al. (2023) and Zubović et al. (2019)

statistics. The likelihood ratio (LR) test suggests that the presented probit models (Model 1, which include only the covariates later used in the intensity equation, and Model 2, which also includes variables identifying the sample selection, that is, the alcohol consumption prevalence and the degree of urbanization) are at the five-percent level significantly different from an alternative intercept model, although the value of McFadden's Pseudo R^2 coefficient indicates that log-likelihood gains compared to the intercept model are rather minimal.

Nevertheless, these models apparently do correctly classify predicted outcomes, since the Hosmer-Lemeshow goodness-of-fit test is in both cases statistically insignificant. Additionally, both models pass the specification link test, indicating that the squared residuals do not have sufficient explanatory power. Regarding additional descriptive statistics, the number of observations differs among models as Roodman's (2008) conditional recursive mixed-process estimator used for Model 3 reports the number of all the observations used for estimation of any of the individual equations, not just the smoking prevalence equation.

Regarding the HS model (Model 3), the results of the Wald test of error correlation with the smoking intensity equation (presented in the Link test row) indicates that the two equations are independent, which is why the standard 2PM approach as presented by Model 1 should be sufficient for fully capturing Slovak cigarette consumption.

Table 1. Smoking prevalence elasticity estimates

	Model 1	Model 2	Model 3
Log of cluster average of cigarette unit values	-0.177**	-0.164*	-0.164*
	(0.090)	(0.091)	(0.091)
Log of total household expenditures	0.150***	0.132**	0.129**
	(0.053)	(0.054)	(0.054)
Log of household size	0.247***	0.183***	0.182***
	(0.055)	(0.057)	(0.057)
Average age of household members	0.006**	0.005**	0.005**
	(0.002)	(0.002)	(0.002)
	0.079***	0.081***	0.081***

The household is owner of its residence			
	(0.029)	(0.029)	(0.029)
Children present in the household	-0.118	-0.104	-0.102
	(0.073)	(0.074)	(0.074)
Employment status of the reference person (Unemployed)	0.735***	0.717***	0.715***
	(0.232)	(0.231)	(0.231)
Employment status of the reference person (Pensioner)	-0.313***	-0.322***	-0.322***
	(0.065)	(0.065)	(0.065)
Employment status of the reference person (Disabled)	-0.007	-0.011	-0.008
	(0.144)	(0.146)	(0.146)
Employment status of the reference person (Student)	0.206	0.215	0.210
	(0.578)	(0.588)	(0.588)
Employment status of the reference person (Other inactive person)	0.328	0.286	0.287
	(0.406)	(0.409)	(0.410)
Alcohol consumption prevalence		0.207***	0.224***
		(0.051)	(0.051)
Degree of urbanization (Average)		0.086*	0.081
		(0.050)	(0.050)
Degree of urbanization (Sparse)		0.167***	0.162***
		(0.053)	(0.053)
Constant	-2.752***	-2.731***	-2.716***
	(0.538)	(0.544)	(0.544)
Joint estimation with other equations	No	No	Yes

El. (Price)	-0.222**	-0.206*	-0.206*
	(0.113)	(0.114)	(0.114)
El. (Exp)	0.187***	0.166**	0.162**
	(0.067)	(0.068)	(0.068)
N. of Obs.	4627	4627	4633
ll	-2607.994	-2594.483	-4394.500
Pseudo R^2	0.025	0.030	
VIF	4.058	4.086	
LR test	134.563	161.584	
	0.000	0.000	
Link test /	0.328	0.417	*2.817*
Cor. err.	0.743	0.677	*0.093*
HL test	9.057	5.647	
	0.337	0.687	

Note: Table 1 presents the smoking prevalence price [El. (Price)] and expenditure [El. (Exp)] elasticity estimates for Slovakia based on 2020 HBS Data, using the two-part model (Model 1) approach and Heckman sample selection approach (Model 3). Corresponding standard errors are reported in parentheses, and the statistical significance at the 0.1, 0.05, and 0.01 level is indicated by "*", "**", and "***", respectively. The 2PM in case of the prevalence elasticity translates into ordinary probit estimates for baseline model and model expanded with additional variables for identification of sample selection (Model 2, see "Heckman sample selection approach" in "Methodology" section). The Heckman (HS) model is obtained using Roodman's (2008) conditional recursive mixed-process estimator, which models the error terms of multiple equations as jointly normally distributed. Additionally, corresponding number of observations (N. of Obs.), and values of the log-likelihood function (ll), McFadden's pseudo coefficient of determination (Pseudo-R^2), maximal obtained variance inflation factor (VIF), model joint statistical significance likelihood ratio test (LR), specification link test (Link test), and Hosmer-Lemeshow goodness-of-fit (HL) test are reported. The correlation of the error terms (Cor. Err.) is tested using standard Wald test, which is reported in italics, using the Link test row in case of the correlation of the prevalence equation with the smoking intensity (conditional demand) equation. Corresponding p-values of all the aforementioned tests are reported below each statistic. The estimates of entire Model 1, Model 2, and Model 3 are available in the attached file "digital_appendix_2pm_prevalence.xlsx" as specifications (1), (2), and (5), respectively.

The smoking prevalence price elasticity (that is, the price elasticity of cigarette consumption at the extensive margin) appears to be consistently slightly greater than -0.2. To be diligent, the estimate of -0.222 by the 2PM approach (Model 1) should be more appropriate than the HS model (Model 3), given the result of the corresponding error correlation test. Similarly, the estimate of prevalence expenditure elasticity at the value of

0.187 provided by the 2PM approach (Model 1) is considered to be most reliable. To put the obtained estimates into a broader context, if cigarette price increases by one percent, the prevalence of smoking decreases by 0.222 percent. Similarly, if the expenditures of households increase by one percent, the prevalence of smoking rises by 0.187 percent.

From other covariates included in the main specification, smoking prevalence appears to be statistically significantly affected at the five-percent level by variables of household size, average age of household members, households' ownership of its residence, and the reference person being unemployed—which all appear to increase the likelihood of the household containing a smoker. On the other hand, the only statistically significant control variable at the five-percent level in the main specification that decreases smoking prevalence is the indicator variable of the reference person being a pensioner.

Intensity elasticity

Obtained results of intensity elasticities (that is, price and expenditure elasticities of cigarette consumption at the intensive margin) presented in Table 2 in many regards mirror those for smoking prevalence. As before, the individual model is jointly statistically significant and passes the specification link test. The error correlation test indicates that the 2PM approach (Model 1) is more appropriate than the HS model (Model 2). Consequently, 2PM estimates suggest that smoking intensity own-price elasticity is at a value of -0.784 and that smoking intensity expenditure elasticity is 0.657, both of which are statistically significant at the five-percent level. Put differently, if cigarettes price increases by one percent, the consumption of cigarettes, conditional on the fact that the household contains a smoker, decreases by 0.784 percent. Analogously, if the expenditures of a household increase by one percent, conditional consumption of cigarette increases by 0.657 percent. The obtained magnitude of conditional price elasticity is in line with the previous measure of own-price intensity elasticity for Slovakia provided by Jamrich and Pokrivčák (2018), which was, at a magnitude of -0.921, also in the higher range of comparable countries.

Table 2. Smoking intensity (conditional consumption) elasticity estimates

	Model 1	Model 2
Log of cluster average of cigarette unit values	-0.784***	-0.831***
	(0.141)	(0.144)

Log of total household expenditures	0.657***	0.687***
	(0.082)	(0.084)
Log of household size	-0.143*	-0.086
	(0.082)	(0.090)
Average age of household members	-0.005	-0.004
	(0.003)	(0.004)
The household is owner of its residence	0.016	0.034
	(0.041)	(0.043)
Children present in the household	-0.141	-0.168
	(0.106)	(0.108)
Employment status of the reference person (Unemployed)	0.099	0.240
	(0.268)	(0.284)
Employment status of the reference person (Pensioner)	0.113	0.040
	(0.099)	(0.109)
Employment status of the reference person (Disabled)	0.168	0.173
	(0.219)	(0.221)
Employment status of the reference person (Student)	-1.426*	-1.367*

	(0.752)	(0.761)
Employment status of the reference person (Other inactive person)	0.053	0.131
	(0.537)	(0.544)
Constant	0.340	-0.489
	(0.835)	(0.975)
Joint estimation with other equations	No	Yes
El. (Price)	-0.784***	-0.831***
	(0.141)	(0.144)
El. (Exp)	0.657***	0.687***
	(0.082)	(0.084)
N. of Obs.	1226	4633
ll	-1801.033	-4394.500
R^2	0.088	
VIF	3.501	
F test /	10.692	*2.817*
Cor. err.	0.000	*0.093*
Link test	-0.503	
	0.615	

Note: Table 2 presents the smoking intensity price [El. (Price)] and expenditure [El. (Exp)] elasticity estimates for Slovakia based on 2020 HBS Data, using the two-part model (Model 1) approach and Heckman sample (Model 2) selection approach. Corresponding standard errors are reported in parentheses, and the statistical significance at the 0.1, 0.05, and 0.01 level is indicated by "*", "**", and "***", respectively. The 2PM in case of the intensity elasticity translates into ordinary least squares (OLS). The Heckman (HS) model is obtained using Roodman's (2008) conditional recursive mixed-process estimator, which models the error terms of multiple equations as jointly normally distributed. Additionally, corresponding number of observations (N. of Obs.), and values of the log-likelihood function (ll), coefficient of determination (R2), maximal obtained variance inflation factor (VIF), model joint-statistical significance F-test, and performed specification link test (Link test) are reported. The correlation of the error terms (Cor. err.) is tested using the standard Wald test, which is reported in italics, using the F-test row in case of the correlation of the intensity equation with the smoking prevalence equation. Corresponding p-values of all the aforementioned tests are reported below each

statistic. The estimates of entire Model 1 and Model 2 are available in the attached file "digital_appendix_2pm_intensity.xlsx" as specifications (1) and (3), respectively.

QUAIDS total elasticity

For an additional robustness check of the results for price and expenditure elasticity, the QUAIDS model approach was utilized. This approach depicts the consumption expenditures of households as a demand system covering all expenditures. Given the complexity of the expenditures, their detailed data were aggregated to 11 consumption groups with products of relatively homogenous nature, following the work of Dybczak et al. (2014) and serving to the focus of the study. The expenditure groups are as follows: (1) Food and beverages; (2) Alcohol; (3) Factory-made cigarettes; (4) Other tobacco products; (5) Clothing; (6) Energies; (7) Furniture and home electronics; (8) Health and body care; (9) Education and leisure; (10) Transportation and communication; and (11) Other products and services.

To calculate the prices for all of the expenditure groups', monthly data of household consumption and prices were utilized. Weighted averages for these variables were calculated on the basis of the expenditure subgroup as shares of a higher group. This approach was not utilized in the case of cigarettes, for which unit values and clustering on the primary sampling unit level, described in more detail in the Data section, were used.

The results of the aforementioned specification of the QUAIDS model are presented in Table 3.[9] Model estimated elasticities are significant at the one-percent level with the exception of health-related expenditures and other tobacco products' own-price elasticities. This might be a result of the fact that expenditures related to health are not easily substitutable for other products or services. All signs of the elasticities are in line with expectations. Estimated own-price elasticity for the consumption of cigarettes was for the data covering years 2018–2021 at a level of -1.195. In other words, if cigarette price increases by 10 percent, the total consumption of cigarettes decreases by around 12 percent. This might seem to be a relatively high estimate, given the expectations based on other studies. However, in the period analyzed, the presence of alternative products such as e-cigarettes, heated tobacco products, and nicotine pouches became more significant. Thus, consumers shifting to alternative products that are not covered in the dataset might be a partial explanation of a relatively higher level of price elasticity compared to other studies. Results of the estimation of expenditure elasticity for cigarettes consumption was 0.970. Put differently, an increase of 10 percent in total

[9] Robustness estimates results are presented in the Appendix.

expenditures of households results in a 9.7-percent increase in expenditures on cigarettes.

Table 3. Total elasticities, QUAIDS

	Elasticity	
	Price	Expenditure
Cigarettes	**-1.195*** **	**0.970*** **
	(0.415)	(0.089)
Other tobacco products	**1.605**	**0.599** **
	(1.764)	(0.259)

Source: Authors' calculations

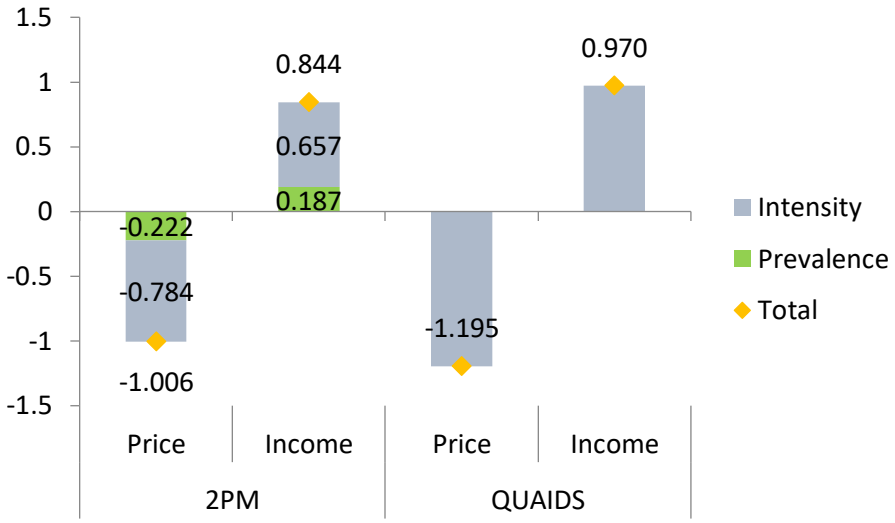
Total elasticities

Subsequently, the total price and expenditure elasticities of cigarette consumption are determined by aggregating the respective prevalence and intensity elasticities. The two approaches of the 2PM and the QUAIDS allow for computing alternative estimates and, thus, providing insight into the potential effect of the choice of method applied on the obtained results.

As is depicted in Figure 3, the total price elasticity of cigarette demand based on the 2PM approach is -1.006 and, according to the QUAIDS estimates, -1.195. Thus, a one-percent increase in cigarette prices would result in a 1.006-percent to 1.195-percent decrease in overall cigarette consumption, depending on the model approach. In both cases, the predominant share of the effect comes from the intensity elasticity: that is, existing smokers continuing to smoke but deciding to decrease their daily intake, rather than the prevalence elasticity, which is existing smokers deciding to quit smoking.

Similar conclusions can be drawn also for the expenditure elasticity, for which alternative total elasticities are 0.844 and 0.970, based on the 2PM and the QUAIDS, respectively. To put those numbers into perspective, a one-percent increase of household expenditures would result in a 0.844-percent to 0.970-percent increase in cigarette consumption, depending on the approach used for the estimation.

Figure 3. Total cigarette consumption elasticities based on 2PM and QUAIDS estimates



Source: Authors' estimates based on 2020 Slovak HBS data

Policy measure simulation

Baseline information for a policy measure simulation (see Table 4) was obtained from country-level records regarding declarations on excise duty on tobacco products:

- The weighted average price of 1000 cigarettes for 2022 was obtained from the Financial Administration of the Slovak Republic.
- The consumption of cigarettes available from the IFP, the Ministry of Finance of the Slovak Republic, over the period January 2022–December 2022 was used as the baseline consumption level for the purposes of the simulation.
- The specific excise duty for cigarettes (which historically changed in February 2022) was computed as the weighted average of specific excise duties used over the period January 2022–December 2022, with the amounts of cigarettes taxed with combined excise duty serving as weights.
- The baseline tax revenue for 2022 was computed as a product of the total excise duty per cigarette and total amount of cigarettes consumed.

As a policy shock, an increase in cigarette prices due to an increase in corresponding excise duty was examined. In the projected case, it was assumed that a shift in prices is solely driven by the shift in cigarette excise duty—that is, a full pass-

through was achieved. Two variant policy scenarios were based on two alternative price increases of 10 percent and 25 percent, which were achieved by increasing the total excise duty per stick by 13.81 percent and 34.54 percent, respectively (for more details see Table 4). An additional assumption for all the simulations was that the total expenditures of households would increase by 9.9 percent, based on a June 2023 macroeconomic forecast of the Ministry of Finance of the Slovak Republic for 2023.

Based on the alternative estimates of total cigarette demand elasticity obtained from 2PM and QUAIDS approaches, the consumption in variant scenarios was projected. The reaction of cigarette demand to the price increase is slightly lower for the simulations based on 2PM results than in the case of QUAIDS results, due to the comparably lower value of the total price elasticity.

Table 4. Impact of price on consumption and government budget

		Price per pack	Consumption		Tax revenue	
		(EUR)	(Mil. packs)	(% change)	(Mil. EUR)	(% change)
Baseline		4.25	316.6		811.4	
2PM	Price shock	New price				
	10%	4.67	311.2	-1.7%	907.7	11.9%
	25%	5.31	263.4	-16.8%	908.3	11.9%
QUAIDS	Price shock	New price				
	10%	4.67	309.1	-2.3%	901.8	11.1%
	25%	5.31	252.4	-20.3%	870.3	7.3%

Source: Authors' calculations

Next, the effects of a policy measure, which in February 2023 increased the excise duty on tobacco, were simulated using rather similar settings to those presented in Table 4. Alternative scenarios were based on the following assumptions:

- The specific duty was raised from (the computed) EUR 79.3/1000 cigarettes to (officially set) EUR 84.6/1000 cigarettes.

- Increase in net-of-tax (NOT) price of cigarettes was set to 7.68 percent, which was the simple average of annual NOT price increases in the period 2019–2022 based on the weighted average price of 1000 cigarettes officially published by the Financial Administration of the Slovak Republic. Thus, a full pass-through assumption from the hypothetical scenarios (presented in Table 4) described above was no longer applied.
- The increase in household expenditures was assumed at 9.9 percent, as before, and the historical consumption of cigarettes over 2022 was used as the baseline consumption for the simulation.
- The weighted average price of 1000 cigarettes for 2022 was obtained from the Financial Administration of the Slovak Republic.
- On the basis of the percentage cigarette tax (23 percent of the end-user price), VAT (20 percent of the end-user price), and a cigarette specific duty an average NOT price for 2022 was calculated to be EUR 0.049 per stick.
- The baseline tax revenue for 2022 was computed as a product of the total excise duty per cigarette and total amount of cigarettes consumed.

The alternative projections obtained based on 2PM and QUAIDS estimates (Table 5)[10] of total elasticities indicate that under described circumstances the consumption should increase at a magnitude of 1.2 percent and the tax revenue generated by cigarettes should increase by about 8.1–8.2 percent.

The relatively high total own-price elasticity may also imply that increasing the taxation on cigarettes should be accompanied with similar changes in the groups of vaping, heated tobacco products, and other alternatives, given the potential for substituting cigarettes with those types of products by smokers in recent years.

[10] Alternative estimates of simulations presented in tables 4 and 5 compared to counterfactual scenarios are presented in the Appendix.

Table 5. Specific duty increase from February 2023 simulation

		Price of cigarettes per pack (EUR)	Percentage duty per pack: 23% (EUR)	Specific duty per pack (EUR)	Total excise duty per pack (EUR)	VAT per pack (EUR)	Net of tax (NOT) price per pack (EUR)	Consumption (Mil. packs)	Tax revenue (Mil. EUR)
2PM	2022	4.249	0.977	1.586	2.563	0.708	0.978	316.568	811.392
	2023	4.550	1.046	1.692	2.738	0.758	1.053	320.496 (+1.2%)	877.643 (+8.2%)
								Change	66.251
QUAIDS	2022	4.249	0.977	1.586	2.563	0.708	0.978	316.568	811.392
	2023	4.550	1.046	1.692	2.738	0.758	1.053	320.214 (+1.2%)	876.869 (+8.1%)
								Change	65.477

Source: Authors' calculations

Conclusions and Policy Recommendations

This report provides estimations of price and total expenditure elasticities of cigarette demand and of other tobacco products in Slovakia. To estimate elasticities for manufactured cigarettes two types of model approaches were applied, namely the two-part model and the QUAIDS model. Elasticities of other tobacco products consumption were estimated using only the latter modeling approach. Estimates are based on the last wave of HBS survey data from 2020 that was significantly affected by COVID-19, which should be kept in mind and the results regarded with a certain degree of caution. Nevertheless, both model approaches provided relatively similar estimates of price elasticities of manufactured cigarettes at levels around -1 to -1.2 and also for expenditures elasticity of 0.84 to 0.97. Price elasticity of other tobacco products was not statistically significant and, in the case of expenditure elasticity, reaches roughly the 0.6 level.

Using the estimated levels of elasticities and weighted average price (WAPC) of manufactured cigarettes in 2022, two sets of policy simulation scenarios were computed. The first hypothetical simulation with a full pass-through assumption indicated that an increase in prices of at least 10 percent from levels in 2022 would be enough to decrease cigarette consumption and provide additional budget revenues, usable for health care costs and other control measures to tackle tobacco consumption and smoking initiation. There is an apparent limitation of using WAPC, which is the missing information on real prices by brand, especially the proportion of cigarettes sold at the minimum specific rate, but their share was below one percent of total sales in 2022.

The second scenario represents the policy change according to the plan in the 2023 tax calendar, namely an increase in the specific tax by 6.7 percent (to EUR 84.6 per 1000 sticks) accompanied with a 7.7-percent increase in the NOT. Results of this scenario indicate a slight increase in consumption (of 1.2 percent) and in public budget revenues by more than eight percent. From a fiscal perspective, this development appears positive at first sight, but it fails to take into account the effects of increased mortality, health expenditures, and lower productivity as a result of the negative impacts of cigarette consumption proliferation on public health. The expected increased consumption is resulting from relatively high total expenditure elasticity and expected swift increase in total household expenses of 10 percent. To decrease consumption in 2023, an increase in the specific tax to a minimum of EUR 87 per 1000 cigarettes should guarantee that household behavior would not be driven by the expected increase in their total expenditures.

Future changes in the tax levels need to take into account not only price elasticity but also relatively high total expenditure elasticity. Additionally, fostering a decrease in

consumption not only benefits the public budget but also should mitigate related health care costs and productivity losses.

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Appendix

Robustness/Sensitivity of 2PM results

Following the recent example by Cheng and Estrada (2020), potential endogeneity of cigarette prices was also examined using the instrumental variable (IV) approach within the probit model setting. This was done by estimating log likelihoods based on joint densities of error terms, which allowed for correlation among them. Roodman's (2008) routine of conditional mixed-process estimator was used for all of the application of maximum likelihood methods with joint multivariate densities. This way the IV approach and the Heckman approach were examined within a single framework, which also enabled for joint estimation of the Heckman sample selection model with IV for cigarette prices. This model took inspiration from the approach suggested by Wooldridge (2010), which outlines the IV Heckman approach as an iterative three-step procedure.

In line with Cheng and Estrada (2020), the logarithm of minimal excise duty on tobacco in each period obtained from the IFP data was used as one of the instruments for cigarette prices. This slightly deviates from the approach of the aforementioned authors, who used the average tax rate. However, since most of the cigarette packs sold in Slovakia are taxed by the so-called combined rate, which is dependent on the actual price of the pack, the minimal excise duty was used instead to avoid any potential simultaneity between prices and tax rates. Additionally, the per-period weighted average of HICPs for cigarettes of neighboring EU countries obtained from Eurostat was used as an alternative instrument for cigarette prices. A similar approach of using prices in neighboring countries was in the context of elasticity demand discussed by, for example, Zhai et al. (2023).

In order to empirically test that the use of cluster averages of unit values resolves potential endogeneity issues, an identical specification to the one presented in Table 1 and Table 2 was estimated using models based on joint error distributions with IVs, which are presented in Table A1 and Table A2, respectively. As a test of endogeneity, the Wald test statistics presented in Table A1 are statistically insignificant. More specifically, error correlation with the first stage IV regression (First Stage) is statistically insignificant at the five-percent level for all presented models. However, the described application of the IV approach in the context of the Heckman sample selection model (Model 3) should be deemed rather experimental and its results treated with some degree of caution. This disclaimer is necessary due to the fact that the prevalence equation is most likely

estimated as a reduced-form equation rather than a structural equation (Roodman, 2011) as well as suffering from collinearity due to sharing the variables identifying sample selection (Wooldridge, 2010). Because of this, Model 1 and Model 2 are considered more reliable.

Table A1. Smoking prevalence elasticity estimates

	Model 1	Model 2	Model 3
Log of cluster average of cigarette unit values	1.991	2.547**	2.365*
	(1.445)	(1.178)	(1.267)
Log of total household expenditures	0.088	0.062	0.067
	(0.076)	(0.068)	(0.068)
Log of household size	0.292***	0.218***	0.218***
	(0.052)	(0.052)	(0.052)
Average age of household members	0.005*	0.003	0.003
	(0.003)	(0.002)	(0.002)
The household is owner of its residence	0.080***	0.076***	0.078***
	(0.028)	(0.029)	(0.029)
Children present in the household	-0.152**	-0.141**	-0.139**
	(0.070)	(0.067)	(0.068)
Employment status of the reference person (Unemployed)	0.698***	0.623**	0.641***
	(0.244)	(0.251)	(0.248)
Employment status of the reference person (Pensioner)	-0.254***	-0.234**	-0.246**
	(0.095)	(0.099)	(0.098)
	-0.063	-0.091	-0.083

Employment status of the reference person (Disabled)	(0.140)	(0.135)	(0.138)
Employment status of the reference person (Student)	0.077	0.069	0.079
	(0.558)	(0.543)	(0.550)
Employment status of the reference person (Other inactive person)	0.217	0.139	0.155
	(0.400)	(0.388)	(0.393)
Alcohol consumption prevalence		0.154**	0.176**
		(0.067)	(0.070)
Degree of urbanization (Average)		0.158***	0.150***
		(0.049)	(0.052)
Degree of urbanization (Sparse)		0.213***	0.209***
		(0.048)	(0.049)
Constant	1.665	2.799	2.397
	(3.244)	(2.757)	(2.895)
Joint estimation with other equations	Yes	Yes	Yes
El. (Price)	2.396	2.990**	2.806*
	(1.596)	(1.163)	(1.310)
El. (Exp)	0.106	0.073	0.079
	(0.096)	(0.083)	(0.085)
N. of Obs.	4633	4633	4633
ll	-2598.446	-2575.671	-4375.913
Cor. err. (First Stage)	1.523	2.658	2.245
	0.217	0.103	0.134

Cor. err. (Intensity)	0.673	
	0.412	

Note: Table A1 presents the smoking prevalence price [El. (Price)] and expenditure [El. (Exp)] elasticity estimates for Slovakia based on 2020 HBS Data, using the Heckman sample (Model 3) selection model and two-part models (Model 1 and Model 2) while utilizing the instrumental variable (IV) approach via Roodman's (2008) conditional recursive mixed-process estimator, which models the error terms of multiple equations as jointly normally distributed. Corresponding standard errors are reported in parentheses, and the statistical significance at the 0.1, 0.05, and 0.01 level is indicated by "*", "**", and "***", respectively. Additionally, corresponding number of observations (N. of Obs.), and the value of the log-likelihood function (ll) are presented. The correlation of the error terms (Cor. err.) is tested using the standard Wald test of the correlation of the prevalence equation with the first-stage IV equation for cigarette prices (First Stage) and of the correlation of the prevalence equation with the smoking intensity (conditional demand) equation (Intensity). Corresponding p-values of all the aforementioned tests are reported below each statistic. The estimates of entire Model 1, Model 2, and Model 3 are available in the attached file "digital_appendix_2pm_prevalence.xlsx" as specifications (3), (4), and (6), respectively.

Similarly, the Wald test of error correlation with the first stage IV regression (First Stage) is statistically insignificant at the five-percent level also in the case of intensity elasticity estimates presented in Table A2.

Table A2. Smoking intensity (conditional consumption) elasticity estimates

	Model 1	Model 2
Log of cluster average of cigarette unit values	2.958	-0.492
	(3.426)	(2.085)
Log of total household expenditures	0.592***	0.676***
	(0.107)	(0.094)
Log of household size	0.001	-0.080
	(0.159)	(0.119)
Average age of household members	-0.005	-0.004
	(0.004)	(0.004)

The household is owner of its residence	0.039	0.034
	(0.050)	(0.044)
Children present in the household	-0.231	-0.173
	(0.143)	(0.118)
Employment status of the reference person (Unemployed)	0.234	0.233
	(0.336)	(0.289)
Employment status of the reference person (Pensioner)	0.141	0.050
	(0.110)	(0.111)
Employment status of the reference person (Disabled)	0.070	0.163
	(0.255)	(0.228)
Employment status of the reference person (Student)	-1.603*	-1.384*
	(0.866)	(0.763)
Employment status of the reference person (Other inactive person)	-0.042	0.110
	(0.614)	(0.547)
Constant	7.311	0.239
	(6.447)	(4.100)

Joint estimation with other equations	Yes	Yes
El. (Price)	2.958	-0.492
	3.426	2.085
El. (Exp)	0.592***	0.676***
	0.107	0.094
N. of Obs.	4633	4633
ll	-1791.525	-4375.913
Cor. err. (First Stage)	1.705	0.026
	0.192	0.872
Cor. err. (Prevalence)		0.675
		0.411

Note: Table A2 presents the smoking intensity price [El. (Price)] and expenditure [El. (Exp)] elasticity estimates for Slovakia based on 2020 HBS Data, using the two-part model (Model 1) approach and Heckman sample selection approach (Model 2). Corresponding standard errors are reported in parentheses, and the statistical significance at the 0.1, 0.05, and 0.01 level is indicated by "*", "**", and "***", respectively. The 2PM in the case of the intensity elasticity translates into ordinary least squares (OLS). Heckman (HS) models and models utilizing the instrumental variable (IV) approach are obtained using Roodman's (2008) conditional recursive mixed-process estimator, which models the error terms of multiple equations as jointly normally distributed. Additionally, corresponding number of observations (N. of Obs.), and the value of the log-likelihood function (ll) are presented. The correlation of the error terms (Cor. err.) is tested using the standard Wald test of the correlation of the intensity equation with the first-stage IV equation for cigarette prices (First Stage) and of the correlation of the intensity equation with the smoking prevalence equation (Prevalence). Corresponding p-values of all the aforementioned tests are reported below each statistic. The estimates of the entire Model 1 and Model 2 are available in the attached file "digital_appendix_2pm_intensity.xlsx" as specifications (2) and (4), respectively.

Regarding suspiciously high price elasticities obtained for the IV regressions presented both in Table A1 and Table A2, compared to estimates without IV presented in Table 1 and Table 2, the difference might be caused by the instruments being relatively weak, as in each case they are only exhibiting variation in the time dimension. However, since all of the error correlation tests indicate that the correlation is statistically insignificant, accounting for endogeneity, at least in regard to the tested instruments, appears to be unsubstantiated.

Additionally, different combinations of one to two instruments for the cigarette price first-stage regression within the IV approach as well as variables identifying the sample selection equation within the HS approach were examined. Apart from the fact that the HS approach with IVs was not viable for every combination of instruments, the results for the income and price elasticities remained qualitatively unchanged from those obtained when all the instruments and identifying variables were used.

The models presented in tables 1 and 2 were also subjected to changes of explanatory variables included in the models in order to assess whether described qualitative conclusions regarding cigarette consumption elasticities also hold under changing circumstances.

Among these, relatively crucial was the examination of accounting for the time trend within the set of included covariates. This decision was primarily driven by the relatively extensive time period (December 2018–November 2021) covered by the 2020 wave of the Slovak HBS release. Additionally, this control variable was also used by Jamrich and Pokrivčák (2018), who examined multiple waves of HBS within their Heckman sample selection model. Nevertheless, the inclusion of the time trend barely changes the magnitude of estimated elasticities and all of the qualitative conclusions drawn based on the presented models and statistical tests remain unchanged at the five-percent significance level.

The sensitivity of obtained results to using indicator of total household income instead of total household expenditures was also examined in a similar manner. This was done since total expenditures might be endogenous to prices and quantities of consumed cigarettes. The described exercise revealed that prevalence and intensity price elasticities remained very close to estimates obtained when total expenditures were utilized by the model. In both cases, their magnitudes have slightly diminished when total income was used, which resulted in statistically insignificant prevalence price elasticity at the five-percent level. On the other hand, the estimated total expenditure elasticity dramatically decreases to less than half of the previously presented estimate once total income is used instead of total expenditures. The expenditure elasticity drops to almost 0.14 in the case of prevalence and to 0.18 in the case of intensity, and both of these estimates remained statistically significant at the five-percent level. Described changes driven by the variable of total household income appear to be unaffected by aforementioned inclusion/exclusion of the time trend.

The potential for utilizing cross-sectional weights provided with the 2020 Slovak HBS dataset was also explored. For these purposes, all of the presented models were estimated using such household cross-sectional weights (rounded to integers) as

frequency weights for the purposes of estimating weighted regressions. The obtained results were not qualitatively different from those presented in Tables 1 and 2. The total price and income elasticity based on the baseline 2PM for weighted regressions was -0.94 and 0.68, respectively.

Finally, the robustness of the prevalence price elasticity to the model specification used was explored by estimating a wide array of models, selected based on whether the model is jointly passing the specification link test and Hosmer-Lemeshow goodness-of-fit test. The p-value for the cigarette price parameters was exceeding the set five-percent significance level in a substantial number of cases, but it remained statistically significant at the 10-percent level in a substantial number of cases. The significance of the prevalence price elasticity in the presented results should be, therefore, treated with caution, as it might be dependent on the specification selection and in a considerable number of cases the parameter verges on being statistically insignificant. The selection of the presented specification may, therefore, also affect the estimated magnitude of price elasticity, as this particular specification was selected as an example of statically significant elasticities. However, specifications providing lower magnitudes of prevalence price elasticities are also available, although the smoking prevalence price elasticity would be statistically insignificant in such a case.

Robustness/Sensitivity of the QUAIDS approach

The model specification, results of which are presented in Table 3, was altered to provide a check for its validity. First, the clustering procedure on the level of the primary sampling units was broadened and applied to all other consumption groups. The use of this specification led to slight changes for the product in focus (cigarettes), but expenditure and price elasticities remain virtually unchanged at 0.956*** and -1.172***. The same conclusion holds for the expenditure elasticities of other groups of items. In the case of price elasticities, only two of them stand out with a decrease of 40 percent in the case of alcohol consumption and a decrease of 37 percent for the other tobacco product group.[11] The price elasticity for other tobacco products was not different from zero.

As in the case of the 2PM, we tested sensitivity of results using the indicator of total household income instead of total household expenditures. This specification was applied to account for possible endogeneity between the total expenditures and total income of households. The income was implemented as an instrumental variable in its logarithmic transformation. Results based on this specification altered the own-price elasticity in a limited manner, and it stood at -1.211**. Given the fact that the modification of the specification was related to expenditures, it is also mostly reflected in the corresponding

[11] This estimate was not statistically significant.

elasticity. Size of the total expenditure elasticity, therefore, changed to -0.463, but this estimate was not statistically significant. In the case of other tobacco products both estimates were not statistically significant.

As an additional robustness check, we also ran the weighted regressions of the initial model, and the resulting price elasticity for cigarettes stood at -0.834** (s.e. 0.423) and expenditure elasticity 0.795*** (s.e. 0.085). In the case of other tobacco products, elasticities remained virtually unchanged at 0.524** (s.e. 0.265) for income elasticity and for own-price elasticity 2.593 (s.e. 1.811).