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TIME-VARYING ELASTICITIES OF DEMAND FOR CIGARETTES IN SERBIA

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ABSTRACT

Background

This study examines the time-varying relationship between cigarette demand and its key determinants in Serbia. Understanding how price elasticity of demand evolves over time provides important insights for designing effective fiscal and health policies. Given the high prevalence of smoking in Serbia despite frequent increases in tobacco taxes under the excise calendar, analyzing how consumers' sensitivity to price changes develops across different periods is crucial for evaluating the sustainability and effectiveness of tobacco taxation policy.

Methodology

The study employs an econometric framework based on a rolling regression approach to estimate price and income elasticities of cigarette demand using data from Serbian household budget survey. Assuming that elasticities vary over time, a two-part model is employed to separately estimate the prevalence and intensity components of price and income elasticities across 5-year rolling subperiods from 2006 to 2022, resulting in a total of 12 estimation windows.

Results

The empirical analysis shows that both the prevalence and intensity components of cigarette price elasticity tend to fluctuate over time. Changes in the magnitude of total price elasticity appear to be closely linked to variations in the size of price adjustments. Although the prevalence component varies across periods, no evidence is found in support of the hardening hypothesis. The intensity component tends to decline during periods of small and predictable price increases. On the other hand, income elasticity exhibits a steady upward trend throughout the observed period.

Conclusion

The study challenges the conventional assumption of constant price elasticity of cigarette demand by indicating that taxation and pricing practices can induce structural changes in consumption behavior. The results reveal that larger, unexpected price increases lead to stronger demand responses, whereas predictable, moderate tax hikes, such as those currently applied in Serbia, make demand more inelastic, especially regarding smoking intensity. Consequently, the study concludes that tobacco control policies based on regular, predictable tax adjustments are less effective and recommends introducing less predictable, larger tax increases to achieve stronger public health impacts.

JEL codes: I18, D12, H21

Key words: time-varying elasticity, tobacco taxation, cigarette prices, household budget survey, Serbia

1. INTRODUCTION

Tobacco use is still one of the greatest threats to public health despite many efforts made in previous decades to minimize the harm. According to the WHO estimations (WHO, 2023), the use of tobacco is directly responsible for over 8 million deaths each year around the world, whereby this risk is unevenly distributed as 80% of smokers reside in low- and middle-income countries (LMIC). Serbia, a middle-income country, has ratified the FCTC (Framework Convention on Tobacco Control) in 2006, coupled with multiple laws and public health strategies in the subsequent years, and started to implement Tobacco control measures, including the introduction of so-called "excise calendar" within Law on Excises in 2007, which stipulates dynamic of increase in specific taxes. Later amendments of the Law on Excises since 2012 established a practice of semi-annual growth of specific excise predefined over the 5-year period. Over time, industry has responded to excise calendar by constant semi-annual increase in retail price of 10 RSD (approximately 0.08 EUR) regardless of the growth in specific excise, which eventually resulted in highly predictable dynamics and size of changes in retail prices. Amendments of the Law on Excises have also stipulated that specific excise is occasionally subject to indexation for inflation. More specifically, legislation prescribes indexation of cigarette prices if the inflation is above 2%, which has been introduced accordingly during 2023. and 2024.

The initial effects of the introduction of tobacco control measures and excise calendar in Serbia were quite successful. Study of Zubovic et al. (2019) covering period 2006-2017 shows that smoking prevalence (cigarettes) in Serbia sharply declined, from around 49.7% in 2006 to 34.4% in 2014, followed by the respective drop in monthly average of cigarette packs smoked per household. Yet, the same study indicates that over the period 2015-2017 prevalence and intensity of smoking stagnated. According to the more recent data, in 2021 Serbia was the leading European country with 33% daily smokers among the adult population (WHO, 2023), further implying that pace of decline in smoking prevalence substantially slowed down.

One of the likely reasons for the recent failure in reduction of smoking in Serbia is an increase in affordability of cigarettes that has been observed in the last couple of years. According to the latest edition of Cigarette Tax Scorecard (Drope et al., 2024), Serbia received an overall score of 2.5 (out of 5) in 2022, which is comparably lower compared to 2020 (3.25) and 2018 (3.88), indicating a reversed progress on tobacco taxes, meaning that income growth likely exceeded the effect of taxation increase. This difference can be utmost attributed to a decrease in the affordability change score, which was 5 in 2018, 3 in 2020, and 0 in 2022, while the remaining three components of the overall score (absolute price, tax share, and tax structure) received the same ratings in 2022 compared to 2020 (3, 4 and 3, respectively) and highly similar to 2018 (2, 4.5, and 3, respectively). In this study we analyze whether the substantial slowing down in smoking reduction observed since 2015 can be solely attributed to increasing affordability of cigarettes vis-à-vis hypothesis that implementation of control measures, excise calendar in particular, has resulted in structural changes in consumer demand which reduced effectiveness of tobacco taxation over time. Within microeconomic analytical framework, structural changes in consumer behavior are observed through changes in price and income elasticities estimated from consumer demand equations. In other words, switching between different regimes of consumer behavior imposes the concept of elasticity that varies over time in line with regime-switching

dynamics. While studies on varying elasticities of demand for some other goods that are subject to regulated pricing are quite common in the literature, such as demand for electricity (Chern & Bois, 1988; Inglesi-Lotz, 2011; Liddle & Hasanov, 2023) or demand for gasoline (Mikayilov et al., 2020; Kilian & Zhou, 2024), the studies of varying elasticities of demand for tobacco products are extremely rare. Nevertheless, a few existing studies on the subject indicate that these elasticities may vary indeed (Huang et al., 2004; Dautzenberg & Dautzenberg, 2019; Olesiński et al., 2020).

Traditional studies on tobacco demand often assume that price elasticity is constant, using historical data to predict how tax-driven price changes affect public revenue. However, this approach overlooks broader shifts in taxation policies and industry pricing strategies that may influence consumer behavior. This study challenges the assumption of constant price elasticity by analyzing Serbian household budget data from 2006 to 2022.

Therefore, the main objective of this study is to examine whether the price and income elasticities of demand for cigarettes did vary over time and, if so, to examine the following research questions:

1. Does the size of price change affect the size of the respective response of demand for cigarettes, as suggested by Dautzenberg & Dautzenberg (2019);
2. Does the price elasticity of smoking prevalence decline over time, as suggested by "hardening hypothesis";
3. Does the predictable dynamics and size of price changes affect the respective response of demand for cigarettes.

The starting point in our analysis is study of Vladisavljević et al. (2021) that estimated price and income elasticity of demand for cigarettes in Serbia over the period 2006 – 2017 at –0.659 and 1.058, respectively, using data from Serbian household budget surveys We extended analysis with more recent data and applied two-part model to estimate variations in prevalence and intensity elasticities of demand for cigarettes over the period 2006-2022, using data from Serbian household budget surveys.

The rest of the paper is organized as follows. The second section summarizes findings from the rare existing literature on the subject. The Data and methods section presents sources and features of data used, as well as empirical strategy of estimation. Section on stylized facts provides insight into dynamics of cigarette prices and affordability and households use of tobacco products. The Results and Discussion section presents and discusses key outcomes from the empirical estimates. The Conclusion section summarizes key findings and limitations of the research and provides policy recommendations and possible directions for future research.

2. LITERATURE REVIEW

While variations in elasticity of demand for cigarettes within one country were rarely subject of the research, a vast majority of studies examine aggregate price and income elasticities of demand for tobacco products. Before presenting the findings of the studies that focused on time variations in elasticity, we briefly introduce general findings on tobacco price (and income) elasticities from the overall estimations and aggregate data based on different data sources. Using GATS (Global Adult Tobacco Survey) data from 13 LMICs surveyed between 2008 and 2011, Kostova et al. (2014) estimated the total price elasticity of cigarette demand of approximately –0.53 (–0.36 for smoking prevalence and –0.17 for smoking intensity). Nargis et al. (2021) have made separate estimations for 45 high-income countries (HICs) and 124 LMICs using 2007-2016 data from various sources (Euromonitor International, International Monetary Fund, World Bank). Their analysis showed comparable price elasticity of –0.21 for LMICs and –0.36 for HICs but different income elasticities: –0.16 for HICs and 0.32 for LMICs. This might indicate that cigarettes are perceived as inferior products in HICs, where consumption tends to decrease with income growth, while it tends to increase with income growth in LMICs, suggesting that cigarettes are perceived as the normal good in these countries. Similar estimates can be found for single LMICs in the region. For instance, in the case of Bosnia and Herzegovina (Gligorić et al., 2022), where Household Budget Survey data from 2007, 2011, and 2015 were used, the estimations were –1.01 for price elasticity and 0.81 for income elasticity. For Albania, Gjika et al. (2020), using Living Standard Measurement Survey data from 2012, estimated price elasticity of –0.57 and income elasticity of 0.24. Taken together, these data are in line with meta-analytic estimates from the early 2000s (Gallet & List, 2003), which showed an average price elasticity of –0.48, with estimates ranging from –3.12 to 1.41, and income elasticity of 0.42, ranging from –0.80 to 3.03, indicating differences between studies and countries.

Previous studies that tracked the changes in elasticity over time have produced valuable insights. Using cigarette market data from 1961 to 2002 from 42 US states and Washington D.C., Huang et al. (2004) have estimated price elasticity of -0.41 and income elasticity of 0.06. In addition, they observed some specific trends and sharp changes that are worth attention. In general, the magnitude of price elasticity appeared to decline (in absolute value) over time, indicating that as more people quit smoking, the remaining (“hardcore”) smokers become less sensitive to price changes. The sharp decline in the magnitude of price elasticity around 1992 is considered as the consequence of the tax share reaching a bottom value of about 25% of the price. On the other hand, income elasticity was continuously declining (but staying positive), especially since early ‘90s, with some differences in pace of decline depending on the type of income. The fast decline (in absolute value) after 1992 was observed for dividend income elasticity (with slightly negative values after 1996, reaching –0.03 in 2022), suggesting that higher-income individuals with dividend income were quitting or reducing smoking, with anti-smoking campaigns being one of the possible reasons. Similarly, transfer income (i.e., pensions and welfare payments) elasticity also noticeably declined after 1990 (reaching the negative values of around –0.03 in 2001 and 2002), probably because the elderly and the poor faced limitations in affording more cigarette consumption once the price rose. The decline in earning income elasticity was the slowest

compared to the other two components, with a mild increase as of 2000, which authors regarded as the possible counter-cyclical character of tobacco consumption during periods of recession.

Meta-analysis of the several studies from South Africa indicated that price elasticity varies over time. Using data from 1970 to 1989, Van Walbeek (1996) estimated that price elasticity ranges between -0.53 and -1.52. Two later studies (Van der Merwe & Annett, 1998; Van Walbeek, 2000, as cited in Mukong & Tingum, 2020), which used 1970 as the starting point and 1995 and 1998 as the endpoints, estimated price elasticities of –0.69 and –0.60, respectively. Unlike these studies, which are characterized by substantial overlap in the observed period, Boshoff (2008) used quarterly data from 1996 to 2006 and estimated price elasticity between –0.5 and –0.7. On the other hand, Mukong and Tingum (2020) used data from 2008 to 2014 and found that elasticity is –0.43 for economy-price cigarettes and –0.69 for mid-price brands. Altogether, these studies show not only that price elasticity tends to vary but also tends to exhibit a mild decrease (in absolute value) over time. The observed trend might seem to provide a piece of support for the hardening hypothesis, which suggests that once smoking prevalence declines due to "light" smokers quitting, then the remaining "hardcore" smokers tend to be less sensitive to price measures and to intensify their smoking instead. Still, it is important to note that many studies rejected this hypothesis. Using the data from 18 European countries, Fernández et al. (2015) showed that country-level prevalence tends to relate positively to the proportion of highly dependent smokers. Although the correlation was not significant, this indicated the "softening" trend (as opposed to the hardening hypothesis), meaning that the share of highly dependent smokers tends to be lower when the smoking prevalence is lower in the population. Kulik and Glantz (2016) provided additional support for the "softening" alternative using data from 51 US states and 31 European countries. Their study showed that for each 1% decrease in smoking prevalence, quit attempts increase by 0.55% in the US and remain stable in Europe, while the individual-level consumption decreases in both the US and Europe by 0.32 and 0.22 cigarettes per day, respectively. Similar results were reported for Australia and South Korea, where quit attempts and quit rations tend to increase, while the share of "hardcore" smokers tends to decrease when smoking prevalence declines (Brennan et al., 2020; Jung et al., 2024).

Even though a different type of data was used, findings from Poland also indicated time-varying price elasticity. Olesiński et al. (2020) analyzed the 2005-2014 period using retail sales volume and retail prices of the low-price and high-price segments of the cigarette market. The price elasticity of demand for both low- and high-price segments was estimated to be around –0.5 in 2008, ending up at around –1.0 in 2014. However, the hump-shaped pattern of fluctuation was observed for both segments: low-price segment elasticity was declining (in absolute value) as of 2010 when it reached the value of around –0.18, while high-price segment elasticity achieved the lowest level (in absolute value) of approximately –0.18 in 2012. As the authors hypothesized, the changes in elasticity in both segments are likely the consequence of market circumstances, such as the increase in e-cigarette popularity and the rise of shadow market products.

The very important findings on dynamic response in demand for cigarettes to changes in price are also provided by the analysis of Dautzenberg & Dautzenberg (2019). They analyzed the association between magnitude of change in price and change in sales of cigarettes in France (2008-2018), coming up to the conclusion that this relation is not proportional: higher increase in prices leads to more elastic respond in sales of cigarettes. More specifically, they figured out that

an increase in cigarette price higher than 6% produces significant fall in sales (elasticity above -0.8), while increase in price less than 5% is ineffective as it leads to very inelastic respond of demand for cigarettes (elasticity below - 0.5).

While the increase in tobacco taxes stands out as the long-term goal of national fiscal and health policies all over the world, fiscal authorities in most of the countries make *ad hoc* decisions on the exact amount of increase in excises on annual basis. The public announcement of the multiannual schedule of tobacco taxation stipulating exact dates and amounts of increase in tobacco excises a couple of years ahead, which was implemented in Serbia by the introduction of excise calendar, is not commonly applied practice. Some other notable examples of preannounced multiannual schedules of increase in tobacco taxation can be found in New Zealand, Poland and Bulgaria. The government of New Zealand in 2010 adopted a plan to implement 10% annual increase in cigarette excise between 2010-2017 (Li et al., 2017). More recent cases include 2022-2027 excise road map in Poland and 2023-2026 excise calendar in Bulgaria. In 2023, Bulgaria has adopted 4-year excise calendar that prescribes a 5% annual increase of the excise on manufactured cigarettes (Sabev et al., 2023). Excise road map 2022-2027 that was adopted by Polish Government initially envisaged 10% increase in excise on cigarettes, but in 2024 it was updated by increasing excise taxes on cigarettes 25, 20, and 15 percent in the next three years, respectively (The Government of Poland, 2025). Nevertheless, Serbian multiannual schedule of tobacco taxation is distinctive to other similar cases at least by two aspects. First, due to the practice of biannual changes in excises, trend in increase in tobacco taxation appears very smooth. Second, regardless of the size in excise increase, industry responses by 10 RSD increase in price of cigarette pack across all brands, opposite to other countries where industry adjusts prices to size in excise increase and manipulates with prices across market segments.

Since the practice of preannounced multiannual scheduling of tobacco taxation is rarely implemented, the possible association between predictability of increase in tobacco taxes/prices and demand for tobacco products is not frequently explored. One of the rare studies on this subject is work of Li et al. (2017), who explored the short-term behavioral response to the 5th (2014) and 6th (2015) rounds of New Zealand's series of annual tobacco excise increases (a program of pre-announced rises). Using self-reported data collected in the three months before and after each increase, the authors find no statistically significant change in smoking- or product-related behaviors immediately following those two increases, although overall cessation-related activity in the sample was high in the whole period observed. On the other hand, findings of the similar study examining series of uneven tobacco excise increases in Germany between 2002 and 2005 indicates behavioral changes of smokers and significant associations between the height of the price increase and the intentions of smokers to reduce or quit smoking (Hanewinkel & Isensee, 2007).

In the recent couple of years, several studies attempting to estimate elasticities of demand for cigarettes in Serbia has been produced. Initial study (Jovanović et al., 2018) provided price elasticity estimates between –0.76 and –0.62 and income elasticity between 0.34 and 0.39, using the Engle-Granger cointegration method applied to 2002-2016 macroeconomic data, In the subsequent study (Vladisavljević et al., 2020), Deaton's model was applied to 2006-2017 data from HBS, producing estimated price elasticity at –0.639. Later study of Vladisavljević et al. (2021)

combined methods of two-part and Deaton's model to re-estimate both price elasticity and income elasticity, including separate estimations per three income groups (low-, middle-, and high-income). Nevertheless, none of those studies have attempted to examine whether the elasticity of demand for cigarettes varies, i.e. to see if some structural change in demand for cigarettes occurred over time.

3. DATA AND METHODS

Data

To estimate the demand elasticity for cigarettes, the Household Budget Survey (HBS) data are used. HBS is a nationally representative survey on income and consumption of households, conducted as a repeated cross-section. It is implemented by national statistical offices in all European countries under the methodological guidance of Eurostat. The Statistical Office of the Republic of Serbia (SORS) has been conducting HBS annually since 2006, with an exemption in year 2020, when HBS was cancelled out due to Covid-19 pandemic. Therefore, our sample consists of **16 annual HBS** covering the period **2006-2022**, comprising **86,768 observations** in total.

It is important to mention that HBS records consumed quantities of goods and respective value of expenditures, so that prices of cigarettes are computed in two steps. First, prices at the level of households are proxied by the unit costs of cigarette pack, calculated as the ratio between total household expenditure on cigarettes and quantities of cigarette packs consumed (data on consumption of individual household members are not available in Serbian HBS). In the second step, prices at the level of municipality are computed as the average unit cost (if at least three smoking households are recorded within the municipality) and imputed to all households within municipality, in order to mitigate possible issue of endogeneity stemming from the simultaneous determination of demand for cigarette and cigarette prices.

Empirical strategy

The empirical strategy in this study revolves around the idea that the structural changes in smoking behavior over time impose varying elasticities of demand for cigarettes following the respective changes in the parameters describing cigarette demand function. In order to model these variations, empirical strategy applied in this paper utilizes three building blocks. The first one is a general approach to setting up the model for the estimation of the demand elasticity for cigarettes in Serbia. The second block boils down the general approach to estimation of the demand elasticity to the specific approach in estimating time-varying elasticities aiming to analyze covariations between estimated elasticities and changes in prices/income over time. The third block deals with empirical specification of the regression model.

General specification of varying-parameter model

The central assumption of the varying-parameter linear models is the tenet that regression coefficients depend on some covariates. In other words, varying-parameter models are linear in regressors, but their coefficients are changing with the value of other variables. General specification of the varying-parameter linear regression, simplified to only one explanatory

variable and only one covariate modifying regression coefficient, reads as follows (Park et al., 2013)

$$E(Y|X = x, Z = z) = xf(z) \quad (1.1)$$

where Y is a dependent variable, X is an explanatory variable, f is coefficient function and Z is covariate affecting value of coefficient function. The dependence of the regression coefficient on covariate Z implies a special sort of interaction between Z and X: in some cases Z is indistinguishable from X, while in some cases Z can be a special variable such as time (Hastie & Tibshirani, 1993). For instance, in literature dealing with modeling variations in demand for energy, factors such as changes in the structure and development level of an economy, behavioral changes of consumers and new socio-economic or energy-related policies are considered as covariates which may modify response of demand for energy to changes in energy prices. In a similar manner, socio-economic changes and changes in tobacco control and taxation policies can be considered as a possible factor that may induce structural changes in demand for cigarettes with respect to prices.

The major issue with varying-parameter models is the complexity of their econometric estimation, that usually relies on non-standard numeric estimation methods. Yet, in this study we utilize a simple approach of rolling regressions, i.e. regressions applied to rolling subperiods (windows) within total period, similar to Chern & Bouis (1988), Huang et al. (2004), and Kilian & Zhou (2024). The direct benefit of this simplified approach is the possibility to apply standard econometric methods to estimate demand functions (such as two-part model), ending up with time-series of estimated elasticity, which may be very useful to detect structural changes in consumer behavior (Chern & Bouis, 1988). More specifically, the pattern of variations in elasticity over time may reveal if there was some break point in time in which structural change occurred. Subsequently, detected break point can be used to partition sample into subperiods, estimate regressions for subperiods and test hypothesis if difference in responses of demand to variable of interest is indeed statistically significant with respect to break point. We adopted this approach in the context of our study to examine the third research question, whether the predictability of cigarette pricing imposed any change in demand for cigarettes. In addition, the declining trend of estimated prevalence elasticities can be considered as preliminary evidence of hardening hypothesis, then can be further scrutinized by statistical tests. Regarding the first research question, we simply associate time series of price changes with time-series of estimated price elasticities to appraise level of correlation, as described latter in this section.

Two-part model

The first block relies on general setup of two-part model (Belotti et al., 2015) that was further adjusted to model demand elasticity for cigarettes (John et al., 2023). Basically, two-part modelling is an approach to regression analysis that can be applied to random variables which have mixed discrete-continuous distribution (Belotti et al., 2015). More specifically, if random variable y produces two outcomes ($y_i = 0$ and $y_i \geq 0$) frequently enough to believe that there are substantial reasons for separate modeling of those two outcomes, the two-part model provides general framework how to perform it.

In the first part, a binary choice model is utilized to fit probability of observing a positive-versus-zero outcome,

$$\pi(y > 0) = Pr(y > 0|x) = F(x\delta) \quad (1.2)$$

where x is a vector of explanatory variables, δ is the corresponding vector of parameters to be estimated, and F is the cumulative distribution function of error term.

In the second part, an appropriate regression model is utilized to fit positive outcome with respect to explanatory variables, conditional on a probability of having positive outcome,

$$\pi(y|y > 0, x) = g(x\gamma) \quad (1.3)$$

where g is a density function for $y|y > 0$. Subsequently, overall mean reads as the product of expectations from both part of the model,

$$E(y|x) = Pr(y > 0|x) \text{ x } E(y|y > 0, x). \quad (1.4)$$

Over the recent years, many empirical studies apply two-part modelling in estimating demand elasticity for cigarettes with respect to price and income, using data from HBS (Zubovic et al., 2019; Vladisavljevic et al., 2020; Vladisavljevic et al., 2021; Gligoric et al., 2022; Lichner & Ostrihoň, 2024). The empirical strategy based on a two-part model to fit demand for cigarettes using HBS data is described in detail in *Updated Toolkit on Using Household Expenditure Surveys for Research in the Economics of Tobacco Control* (John et al., 2023). The main idea behind this empirical strategy is to use two-part model to model probability of smoking prevalence for the household h in the first part, and then to model intensity of smoking in the second part in case that household h is smoking one. The key points in modeling are:

a) Total sample of n households is divided into subsamples of smoking households n^s and non-smoking households n^{ns}, so that prevalence indicator I_h has two possible outcomes

- $I_h = 1, \ \ h \in n^s$;
- $I_h = 0, \ \ h \in n^{ns}$.

b) The first part of the two-part model uses the full sample n to estimate the probability of prevalence, i.e. probability of observing positive outcome (smoking household) versus zero outcome (non-smoking household). More specifically, the following model is estimated

$$Pr(I_h = 1|x) = F(x_h\delta), \ \ x_h = \{p_h, m_h, x_h^c\}, \quad (1.5)$$

assuming that F takes form of logit function, $f(z) = e^z/(1 + e^z), z = \ x\delta$. Vector of explanatory variables x_h is assumed to contain price p_h and income m_h being key explanatory variables, thus segregated from the control variables

$$x_h^c. \quad (1.6)$$

c) Once when the probability of prevalence is modelled, elasticity of prevalence $\varepsilon_I^{x_j}$ with respect to price or income is estimated using marginal effects at the average as

$$\varepsilon_I^{x_j} = ME_I^{x_j}\left(\overline{x_j}/\bar{I}\right), \ \ x_j = \{p, m\}, \quad (1.7)$$

where marginal effects $ME_I^{x_j}$ count change in the probability of being smoking household for the unit change in key explanatory variable x_j

$$ME_I^{x_j} = \partial Pr(I_h = 1|x)/\partial x_j \quad (1.8)$$

d) The second part of the two-part model uses only subsample of smoking households n^s to model intensity of smoking conditional on a probability that household h is smoking

$$E(y_h|y_h > 0, x) = x_h\gamma \quad (1.9)$$

where y_h denotes demand for cigarettes of household h. The conditional demand for cigarettes can be further estimated using Deaton model (Vladisavljevic et al., 2020; Vladisavljevic et al., 2021; Gligoric et al., 2022) or by Generalized Linear Model (GML) (Zubovic et al., 2019; Lichner & Ostrihoň, 2024), the latter approach being adopted in this study.

e) Similar to case of prevalence, intensity elasticity $\varepsilon_y^{x_j}$ can be computed via marginal effects (Zubovic et al., 2019)

$$\varepsilon_y^{x_j} = ME_y^{x_j}\left(\overline{x_j}/\bar{y}\right), \;\; x_j = \{p, m\} \quad (1.10)$$

while marginal effects in this case will be equal to γ_j following the linear specification of the model.

d) Eventually, total elasticity of demand for the cigarettes ε^{x_j} with respect to price or income will be approximately equal to

$$\varepsilon^{x_j} = \varepsilon_I^{x_j} + \left(1 + \varepsilon_I^{x_j}\right)\varepsilon_y^{x_j} \approx \varepsilon_I^{x_j} + \varepsilon_y^{x_j} \quad (1.11)$$

Time-varying rolling-window elasticities

The second block mainly relies on the work of Huang et al. (2004), who analyzed dynamics of elasticity in USA over the period of 1961-2002, by estimating elasticity for rolling windows of the length 15, 20 and 25 years. Assume that total sample n comprises of the multiannual HBS covering the period of the total length of T years. In that case, set of the rolling-window subsamples of the length L can be formulated as follows

$$n_1^L, \;\; 1, \ldots L;$$
$$n_2^L, \;\; 2, \ldots L + 1;$$
$$\ldots \quad (1.12)$$
$$n_l^L, \;\; l, \ldots L + l - 1;$$
$$\ldots$$
$$n_{T-(L-1)}^L, \;\; T - (L - 1), \ldots, T$$

Where l denotes subperiod $l, \ldots L + l - 1$ covered by the respective rolling-window. Total number of subsamples n_l^L will be equal to $T - (L - 1)$; for instance, if the period covers 20 years and length of the rolling-window length is 5 years, total number of subsamples n_l^L will be 16.

Estimation of the total elasticity $\varepsilon_l^{x_j}$ for each rolling-window subsample results in time series which provides insight into variation of elasticities over considered period T.

Furthermore, if annualized rate of change in average price or income $agr_l(\bar{x}_j)$ over subperiods l is calculated, simple correlation coefficients $\rho^{,\varepsilon^{x_j},\bar{x}_j}$ between elasticities and dynamics of prices/income, $\rho^{,\varepsilon^{x_j},\bar{x}_j} = corr\left(\varepsilon_l^{x_j}, agr_l(\bar{x}_j)\right)$, will provide insight whether the time variations in elasticities are associated with the size of change in key explanatory variables.

Model specification

Apart from key explanatory variables, i.e. price and income, proper empirical estimation of the models (1.5) and (1.9) requires selection of the set of adequate control variables x_h^c. To this end, the previous study by Zubovic et al. (2019) on estimating demand elasticity for cigarettes in Serbia using two-part model with GLM-based estimation of intensity was utilized. Within this study, various specification of the prevalence and demand model are considered (including non-linear specification with squared prices and income), opting for the model with the most suitable statistical features regarding issues of multicollinearity, goodness of fit and heteroskedasticity. Subsequently, the study comes up with the optimal specification of the prevalence and demand empirical models as follows:

$$Pr(I_h = 1|x) = f(\beta_1^I p_h + \beta_2^I m_h + \beta_3^I m_h^2 + x_h^c \delta^c)$$

$$E(y_h|y_h > 0, x) = \beta_1^y p_h + \beta_2^y m_h + \beta_3^y m_h^2 + x_h^c \gamma^c$$

where set of control variables x_h^c include the next socio-demographic variables:

- Household size
- Male ratio
- Adult ratio
- Education
- Region
- Activity status
- Advertising ban (relevant only in estimation of aggregate elasticity)

Description of each of control variables is provided in the Appendix, Table A1. Squared prices are not included in the model specification as they do not appear significant in any of the specifications considered.

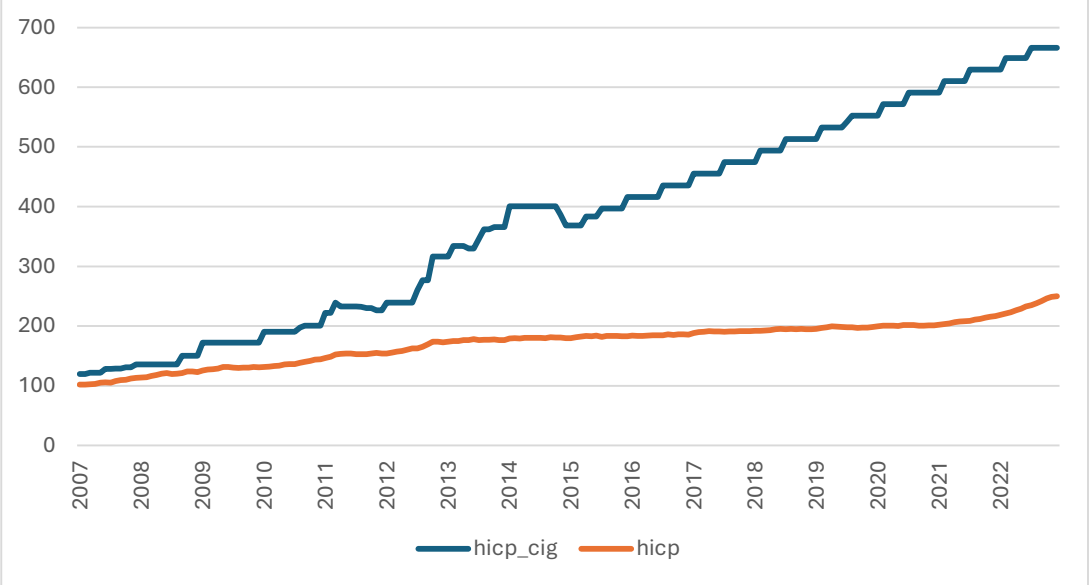
STYLIZED FACTS

Macroeconomic data

According to the data from the Statistical Office of the RS (SORS), prices of cigarettes considerably increased over the period 2006-2022 (Figure 1). Cumulative inflation rate of cigarette prices in 2006-2022 was around 556%, around four times higher than overall inflation rate that counts 134%. The trend in cigarette prices reveals one very important insight. As shown in Figure 1, the period 2006-2014 was characterized by discretionary changes in prices. Since 2015, changes in

prices have been driven by the rules stipulated by the excise calendar, which lead to regular and **highly predictable** changes in cigarette prices. Additionally, it can be noticed that the increase in prices of cigarettes relative to the overall level of prices was more dynamic in the first years of the period considered. More specifically, over the period 2006-2016, cumulative increase in prices was 326%, around 3.85 times higher than increase in overall prices (85%). On the other hand, cumulative increase in cigarette prices over the period 2017-2022 was only 41%, 1.8 times higher than increase in overall prices (23%).

Figure 1. Indices of consumer prices (2006=100), overall, vis-à-vis cigarettes, 2007-2022

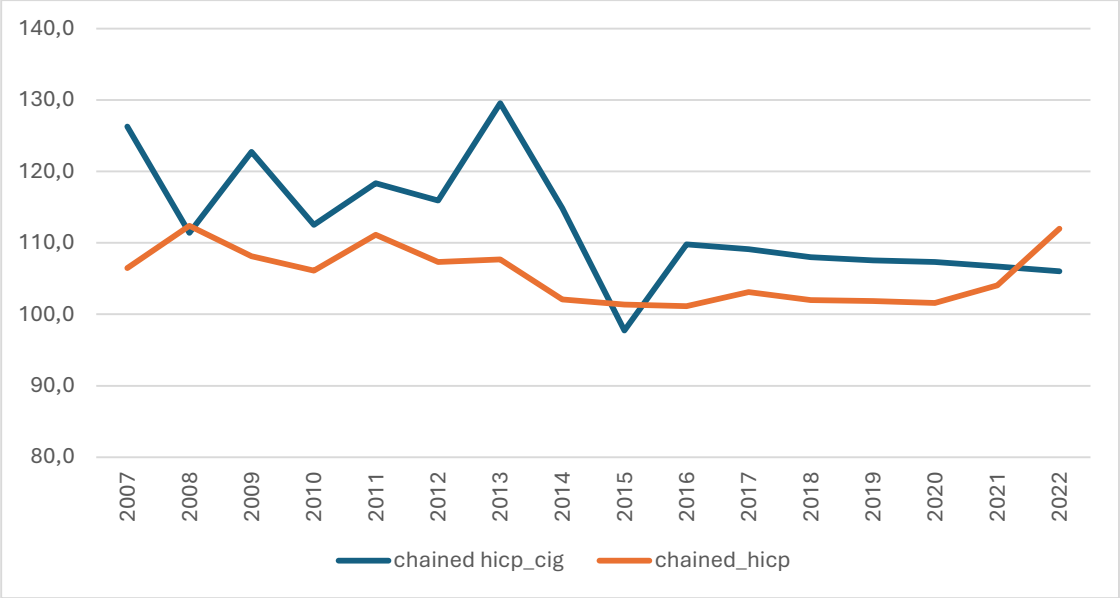


Source: SORS

Note: hicp – overall index of consumer prices, hicp_cig – index of consumer prices of tobacco products

While cumulative change in cigarette prices considerably exceeded the overall level of prices, annual changes in cigarette prices were not always correlated with annual changes in overall prices. This is illustrated in Figure 2, which displays chained indices at the annual level (previous year=100). Until 2014, annual changes in cigarette prices were firmly correlated with and highly above the change in overall prices. In 2015 (year when fiscal consolidation at national level was implemented in Serbia), cigarette prices temporarily declined but bounced back in 2016. Since 2016, annual changes in cigarette prices have been smoothed by the excise calendar, allowing for consumers' price predictability and getting detached from overall inflation. Following the sharp increase in inflation in the post-pandemic period, annual change in cigarette prices eventually equalized with annual inflation by 2022.

Figure 2. Chained indices of consumer prices, overall, vis-à-vis cigarettes, 2007-2022



Source: own calculations based on SORS data

Figure 3. Tobacco affordability index, 2007-2022

Source: own calculations based on SORS data

Note: TAI_GDP -affordability measured by GDP per capita; TAI_wage -affordability measured by average wage.

As mentioned before, an increase in cigarette prices doesn't always mean that tobacco products become less affordable, in case that increase in income offsets the increase in prices. Affordability of cigarettes over the period 2007-2022, measured by the tobacco affordability index (TAI) is displayed in Figure 3. TAI is calculated as the real annual change in GDP or real annual change in average wage, adjusted by the ratio of inflation in tobacco prices and the overall inflation rate

(Zubovic et al., 2024). Therefore, a decreasing value of TAI means that cigarettes become less affordable. As shown in Figure 3, the affordability of cigarettes was very volatile regardless of which TAI measure was used. Nevertheless, it can be noticed that on average affordability was on decline until 2014; since 2015, affordability has been on the rise, especially in the years 2021 and 2022.

HBS data

Data from HBS were used to produce descriptives describing trends in use of the cigarettes in Serbia over the period 2006-2022 (Table 1). Smoking prevalence, defined as the share of the households that reported cigarette expenditures, has significantly declined over the observed period: from 49.7% in 2006 to 30.3% in 2022 (cumulative decline 19.4 percentage points). Yet, the long-term decline in prevalence has reversed in 2022, which corresponds to the increase in affordability observed in Figure 3.

As mentioned before, HBS does not collect data on prices, so real prices are proxied by the

Table 1. Cigarette use in Serbia, weighted descriptives, 2006-2022

Year	Prevalence (% of smoking households)	Average real price (RSD) of cig. pack, 2006=100	Average number of cigarettes smoked (in packs) per household	Average real expenditure on cigarette per household		Average share of expenditure on cigarette in smoking households' budget	
				smoking	all	smoking	all
2006	49.75%	51.93	39.11	1,988	989	5.83%	2.90%
2007	47.93%	58.68	39.22	2,279	1,092	6.63%	3.18%
2008	44.13%	59.05	39.02	2,268	1,001	6.53%	2.88%
2009	42.00%	63.22	37.87	2,353	988	7.01%	2.94%
2010	38.82%	65.84	36.99	2,440	947	7.15%	2.77%
2011	38.42%	68.77	36.17	2,486	955	7.53%	2.89%
2012	38.03%	75.90	34.31	2,607	992	7.86%	2.99%
2013	35.06%	92.81	29.56	2,758	967	8.44%	2.96%
2014	34.44%	105.43	27.69	2,922	1,006	8.84%	3.04%
2015	36.28%	103.45	28.91	2,985	1,083	8.85%	3.21%
2016	33.81%	110.44	29.21	3,234	1,093	9.42%	3.17%
2017	34.24%	117.70	27.24	3,241	1,110	9.33%	3.19%
2018	32.23%	123.02	28.84	3,581	1,154	10.04%	3.24%
2019	31.65%	129.18	31.36	3,737	1,183	10.37%	3.28%
2021	28.96%	142.79	28.15	4,034	1,169	10.46%	3.03%
2022	30.31%	140.47	26.94	3,785	1,147	10.31%	3.13%

Source: own calculations based on HBS data

average unit costs of cigarettes reported by households within one municipality, adjusted for overall inflation. The average real price of cigarettes increased from 52 RSD in 2006 to 140.5 RSD in 2022 (in 2006 RSD), indicating that the cigarette real price cumulatively increased around 2.7 times. Besides the decline in prevalence, households have also decreased smoking intensity from

39 packs monthly on average in 2006 to 27 packs per household (cumulative decline 31%). Nevertheless, stagnation in smoking intensity can be observed since 2013.

Increase in cigarette prices at a higher pace than decline in smoking intensity resulted in gradual increase in average real expenditure on cigarette per smoking household that almost doubled from around 2,000 RSD in 2006 to 3,785 RSD (in 2006 RSD). On the other hand, the increase in average real expenditure on cigarettes is at a higher pace than real increase in disposable income resulting in increased share of expenditure on cigarettes in smoking household' budget from 5.8% to 10.3%.

5. RESULTS

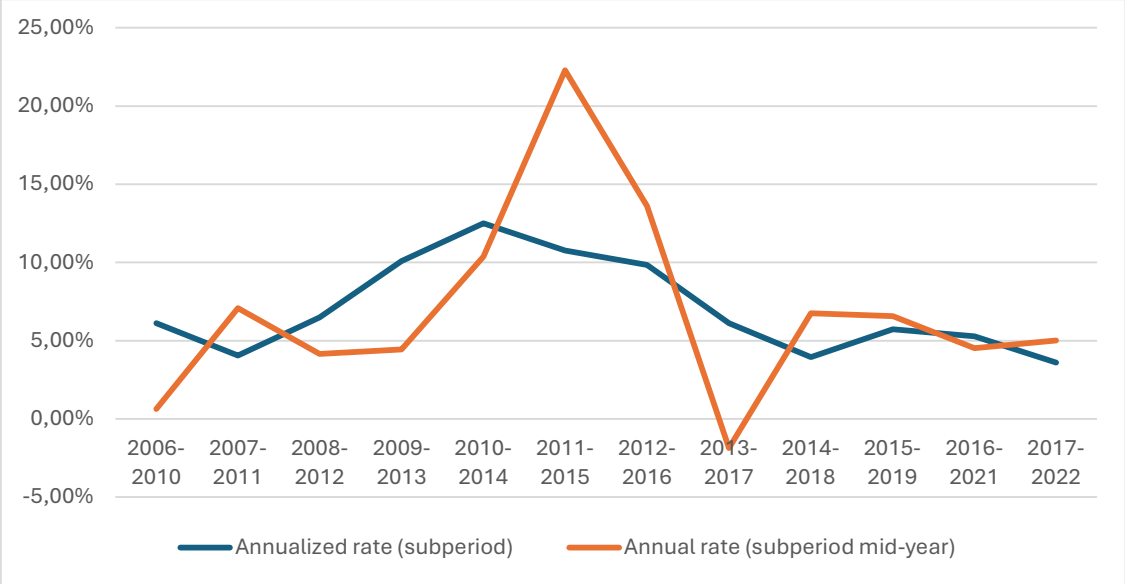
Rolling windows

The first issue that arises in estimation of the time-varying elasticities is selection of the proper length of the rolling window. We tested several lengths ranging from 3 to 7 years, coming to the conclusion that 5-year rolling window is the optimal choice. The rolling windows of the length 3-4 years produces instable elasticity estimates due to insufficient number of observations, while the rolling windows of the length 6+ years produces oversmoothed elasticity estimates since total sample covers 16 annual HBS.

Following (1.12), choice of 5-year rolling-window results in 12 subsamples n_l^5. Number of observations covered by subsamples n_l^5 vary from 22,832 for the subperiod 2009-2013 to 32,041 for the subperiod 2015-2019. This is the consequence of the change in number of observations covered by the HBS, which varies around 4,500 until 2014 when coverage has been increased up to 6,000 – 6,500 observations. Having in mind that HBS was not conducted in 2020, the last two rolling windows actually covered 6-year periods 2016-2021 and 2017-2021, but effectively comprises observations from the five annual HBS as in case of other rolling windows.

The rationale for using rolling windows reflects in the possibility of "smoothing" volatile growth rates and observing trends in change of prices more clearly than in case when annual growth rates are simply used. Additionally, under assumption that magnitude of demand elasticity covaries with recent change in prices, elasticity computed over the longer periods of time may diverge from the recently observed elasticity by giving to much significance to the "old" observations. Both points are illustrated in Figure 4, which shows a comparison between annualized rate of change in cigarette prices over the rolling subperiods and annual rates from the subperiod mid-year (e.g. if subperiod is 2007-2011, mid-year is 2009).

Figure 4. Real changes in cigarette prices, annualized subperiod rates vis-à-vis subperiod mid-year rates



Source: own calculations based on HBS data

Aggregate elasticity estimates

Table 2 shows aggregated estimates of the elasticity of demand for cigarettes over the period 2006-2022 using two-part modelling with GLM estimation of intensity model.

Table 2. Estimates of aggregate demand elasticities in Serbia using two-part model

	Elasticity component	GLM, log	GLM, level	GLM, log	Deaton
		2006-2022	2006-2022	2006-2017	2006-2017
Total	Price	-0.686	-0.706	-0.714	-0.659
	Income	1.133	0.864	1.024	1.058
Prevalence	Price	-0.310	-0.311	-0.265	
	Income	0.647	0.475	0.609	
Intensity	Price	-0.374	-0.345	-0.450	-0.395
	Income	0.449	0.416	0.413	0.447

Source: own calculations, Zubovic et al., 2019

The primary model is specified with price and income in log terms, while model with price and income in levels is applied for the sake of testing robustness of estimates. Estimation details of log model is presented in Table 3, while estimation of model in levels is provided in the Appendix (Table A2). Additionally, robustness of the estimates is assessed by comparison with the work of Zubovic et al. (2019), who estimated elasticities for the period 2006-2017 using two-part model in two versions, with GLM and Deaton modelling of intensity elasticity.

Table 3. Aggregate elasticities' estimates 2006-2022, two-part model in logs

VARIABLES	Prevalence		Intensity	
	Coeff.	St. error	Coeff.	St. error
Real cigarette price	-0.495**	(0.063)	-0.374***	(0.030)
Real monthly household income	1.404***	(0.055)	0.587***	(0.026)
Real monthly household income squared	-0.224***	(0.022)	-0.056***	(0.010)
Household size	0.060***	(0.008)	0.035***	(0.003)
Male ratio	0.548***	(0.035)	0.173***	(0.016)
Adult ratio	0.526***	(0.061)	0.276***	(0.029)
Education (Referent - Incomplete primary)				
Primary	0.510***	(0.049)	-0.008	(0.025)
Tertiary 2 years	0.564***	(0.049)	-0.034	(0.024)
Secondary 4 years	0.294***	(0.050)	-0.126***	(0.026)
Tertiary 2 years	0.044	(0.055)	-0.176***	(0.027)
Tertiary 3+ years	-0.240***	(0.054)	-0.238***	(0.027)
Region (Referent – Belgrade region)				
Vojvodina	0.079*	(0.044)	0.059**	(0.026)
Sumadija and Western Serbia	0.321***	(0.044)	0.097***	(0.018)
Eastern and Southern Serbia	0.078*	(0.046)	0.155***	(0.019)
Activity status (Referent - Employed)				
Unemployed HH	0.119**	(0.047)	0.074***	(0.023)
Pensioner HH	-0.618***	(0.025)	0.010	(0.028)
Self-employed HH	-0.182***	(0.030)	-0.008	(0.012)
Advertising ban	-0.170***	(0.049)	-0.033*	(0.018)
Constant	-0.371	(0.277)	4.104***	(0.153)
Observations	86,736		86,736	

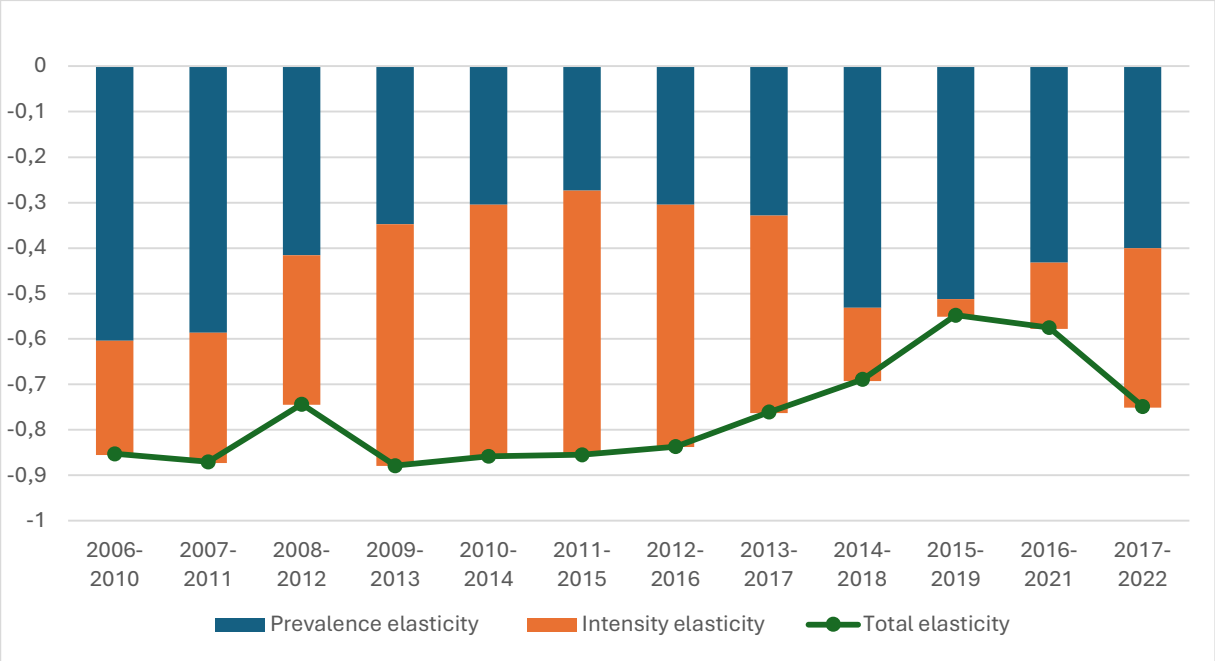
*Note: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1*

Estimates from Table 2 indicate that aggregate elasticities in the long run are quite stable. Estimated price elasticity of demand for cigarettes is inelastic, ranging between -0.66 and -0.71. On the other hand, estimates indicate that income elasticity is close to unit value. Regarding components, results indicate a slight change in composition of price elasticity in favor of prevalence elasticity over the last couple of years.

Rolling windows elasticity estimates

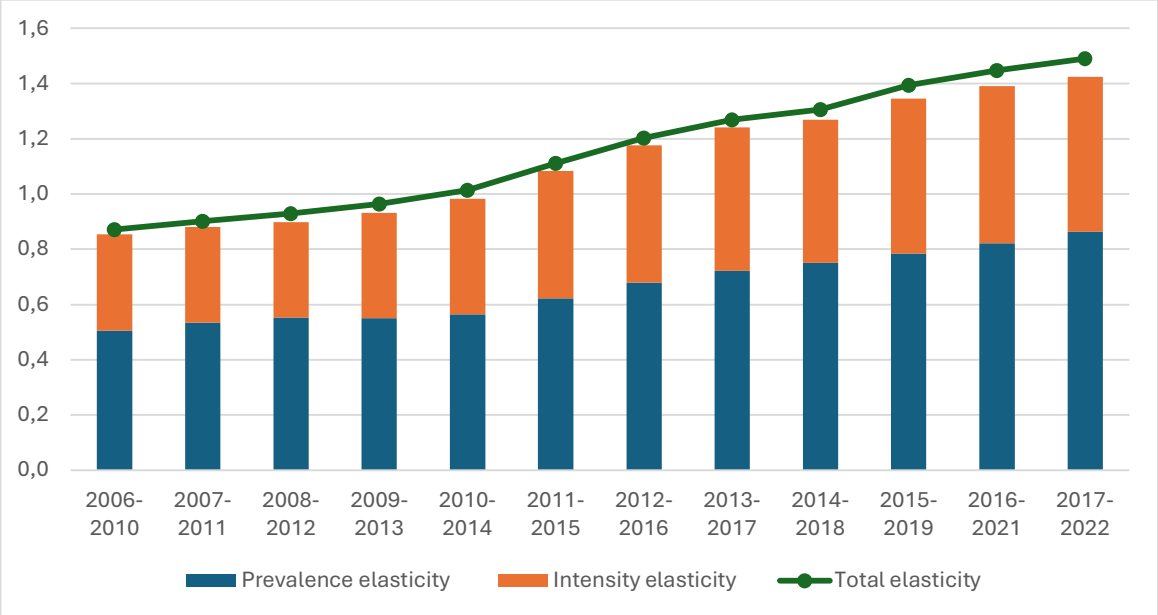
Figure 5 presents a summary of the estimates of the time-varying price elasticities of demand for cigarettes from the log model. Variations in estimated elasticities imply two important findings. First, since the subperiod 2009-2013, total elasticity has been steadily declining until the subperiod 2016-2021, while in subperiod 2017-2022 total elasticity considerably increased. Second, prevalence and intensity elasticity seem to vary in opposite directions since the positive co-movement is not observed in any of subperiods. (in the sense that within the same period both elasticities increased or declined). Anyway, overall trend in total price elasticity is decreasing despite volatility – demand for cigarettes gets more inelastic over time.

Figure 5. Time-varying price elasticity of demand for cigarettes, log model



Source: own calculations based on HBS data

Figure 6 Time-varying income elasticity of demand for cigarettes, log model



Source: own calculations based on HBS data

On the other hand, income elasticity shows a clear trend of increase over the period 2006-2022 (Figure 6). The estimated elasticity increased slightly until the subperiod 2010-2014, when the pace of increase has accelerated. The period of more dynamic increase in income elasticity

roughly corresponds to the period of continues increase in real income, coming after the turbulent period in the aftermath of global crisis.

The variations in elasticity indicated by the figures 5 and 6 are further scrutinized by statistical indicators. More specifically, we consider statistical significance of the estimated elasticities, span of confidence intervals and size of differences between coefficients. The statistical significance of the estimated elasticities for the rolling subperiods, based on z-test, is displayed in Table 4. In the case of income, all estimated elasticities including prevalence and intensity elasticities are significant at 0.01 level. Regarding price, all total and prevalence elasticities are significant at least at 0.05 level. Intensity elasticities appear significant in most of subperiods, apart in subperiods 2014-2018, 2015-2019 and 2016-2021, which correspond to the lowest values of intensity elasticity estimates observed at Figure 5. In other words, statistical tests suggest that in the subperiods mentioned above total elasticity might be fully driven by the prevalence elasticity.

Table 4. Statistical significance of the estimated elasticities from log model, rolling subperiods

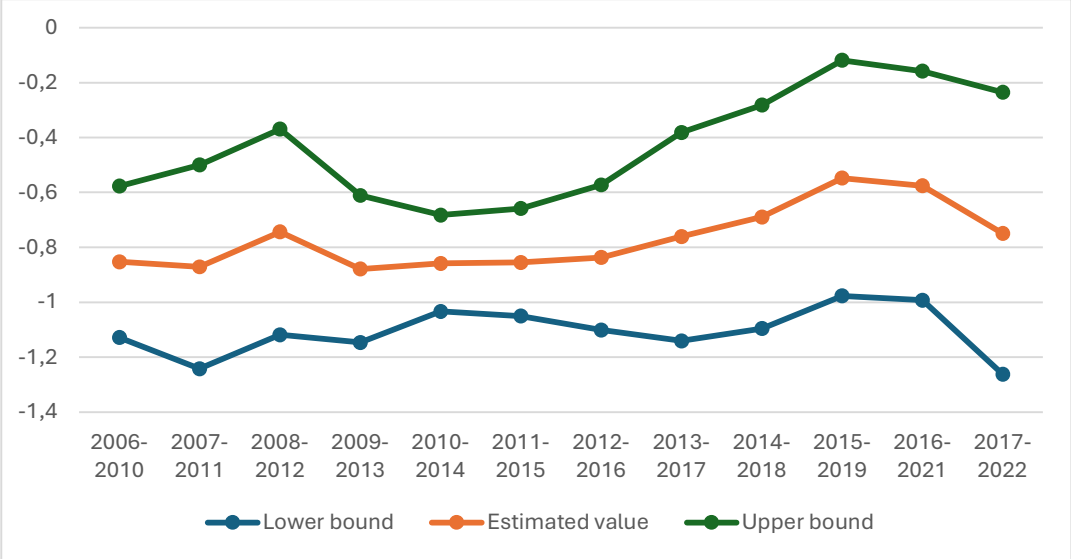
	Price			Income		
Subperiod	**Prevalence**	**Intensity**	**Total**	**Prevalence**	**Intensity**	**Total**
2006- 2010	-0.6035***	-0.2521***	-0.8524***	0.5046***	0.3493***	0.8712***
2007- 2011	-0.5857***	-0.2875***	-0.8706***	0.5337***	0.3468***	0.9022***
2008- 2012	-0.4163**	-0.3287***	-0.7437***	0.5531***	0.3458***	0.9288***
2009- 2013	-0.3472***	-0.5325***	-0.8790***	0.5508***	0.3816***	0.9638***
2010- 2014	-0.3049***	-0.5532***	-0.8581***	0.5649***	0.4187***	1.0137***
2011- 2015	-0.2733***	-0.5812***	-0.8544***	0.6223***	0.4607***	1.1112***
2012- 2016	-0.3048***	-0.5330***	-0.8369***	0.6800***	0.4964***	1.2026***
2013- 2017	-0.3282**	-0.4348***	-0.7611***	0.7225***	0.5188***	1.2687***
2014- 2018	-0.5311***	-0.1618	-0.6886***	0.7512***	0.5187***	1.3058***
2015- 2019	-0.5124***	-0.0388	-0.5477**	0.7846***	0.5604***	1.3936***
2016- 2021	-0.4319**	-0.1458	-0.5751***	0.8220***	0.5686***	1.4476***
2017- 2022	-0.4003**	-0.3509**	-0.7488***	0.8633***	0.5609***	1.4909***

Source: own calculations based on HBS data

*Note: * for p<0.1, ** for p<0.05, *** for p<0.01*

Volatility of total price elasticity is also reflected in volatile span of confidence intervals, as illustrated by Figure 7. The span of confidence intervals seems to be increasing in the last couple of subperiods, particularly from the subperiod 2013-2017, implying that estimated values of total price elasticity in these subperiods are less reliable. Additionally, wide confidence intervals impose inconclusive evidence about significance in difference between estimated elasticities. The similar pattern of variations in confidence intervals is also observed in cases of price prevalence and intensity elasticities, displayed by the figures A3 and A4 in the Appendix.

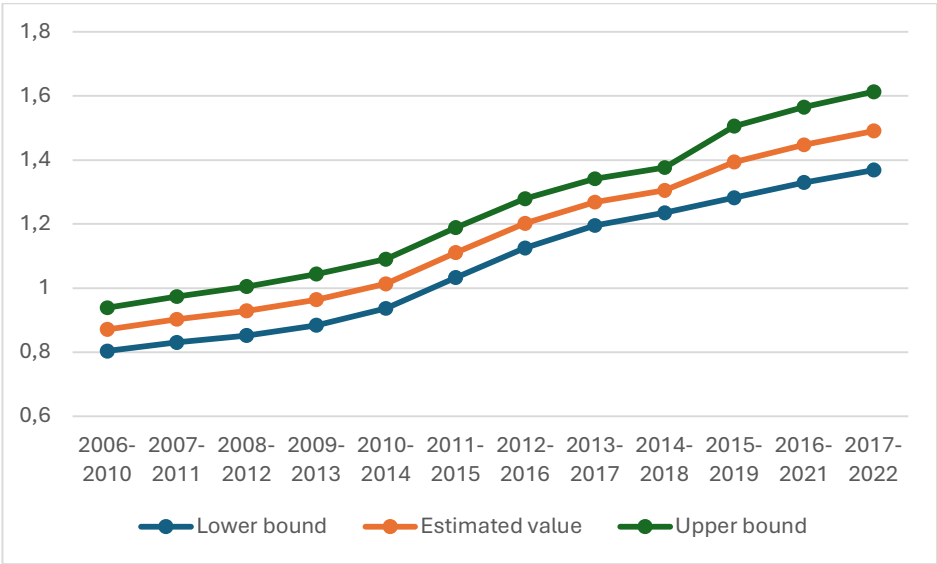
Figure 7. Confidence intervals of the estimated total price elasticities from the log model, rolling subperiods



Source: own calculations based on HBS data

Opposite to the price elasticity, span of confidence intervals for total income elasticity is mostly stable – slight increase is observed only in the most recent subperiods, as illustrated by Figure 7. A similar pattern is also observed for the income intensity elasticity, while in case of income prevalence elasticity span of confidence intervals appears stable throughout all subperiods. Lower bound of confidence intervals for the recent subperiods exceed the upper bound of intervals for the earlier subperiods, indicating that estimated elasticities indeed vary over time.

Figure 8. Confidence intervals of the estimated income elasticities from the log model, rolling subperiods



Source: own calculations based on HBS data

As previously mentioned, span and patterns of confidence intervals in case of income elasticity indicate significant variations, while in case of price elasticity evidence on significance of variations are inconclusive. Therefore, we look for a way to apply more formal testing. We are not aware of any statistical inference that can be applied to regression results from overlapping samples to test joint null that all elasticities are the same against alternative that at least one elasticity is different. Therefore, we used a simplified approach to check if there is any formal evidence on significance in variations. In particular, we looked for the highest and lowest estimates for each elasticity type to check if these estimates do not come from overlapping subperiods. Since the latter turned out to be true, we applied standard z-test for independent samples to test if the difference between highest and lowest estimates is different than zero, which resembles the standard joint alternative hypothesis that at least one pair of estimates is different.

The results of testing are displayed in Table 5. Statistical significance between the highest and lowest estimates of income elasticity is straightforwardly confirmed as expected. On the other hand, findings on the price elasticity are vague. The highest and the lowest estimates seem to be not significantly different, thus indicating that variations in total price elasticity might not be statistically significant. Nevertheless, z-tests suggest that the highest and lowest estimates of prevalence and especially intensity elasticities differ. This finding suggests that even in case that total elasticity did not significantly vary over time, there are strong indications that the structure of the total elasticity did vary over time.

Table 5: Statistical significance of difference between the highest and lowest estimates of elasticity according to elasticity types

	Price		Income	
	Highest estimate	**Lowest estimate**	**Highest estimate**	**Lowest estimate**
Total				
Subperiod	2015- 2019	2009- 2013	2017- 2022	2006- 2010
Estimated value	-0.5477	-0.879	1.4909	0.8712
Difference	-0.3313		0.6197***	
Prevalence				
Subperiod	2011- 2015	2006- 2010	2017- 2022	2006- 2010
Estimated value	-0.2733	-0.6035	0.8633	0.5046
Difference	-0.3302**		0.3587***	
Intensity				
Subperiod	2015- 2019	2011- 2015	2016- 2021	2008- 2012
Estimated value	-0.0388	-0.5812	0.5686	0.3458
Difference	-0.5424***		0.2228***	

Source: own calculations based on HBS data

6. DISCUSSION

Research question 1: Does the size of price change affect the size of the respective response of demand for cigarettes?

The overall associations between elasticities and price and income are examined throughout simple correlations between elasticity estimates and respective annualized subperiod rates of change in price and income, $\rho_{,\varepsilon^{x_j},\bar{x}_j} = corr\left(\varepsilon_l^{x_j}, agr_l(\bar{x}_j)\right)$. Table 6 summarizes these correlations for both log and level models. The positive association between income elasticity and change in income is very high: an increase in income leads to the positive response of both prevalence and intensity components, thus to the positive response of the total income elasticity.

Table 6. Correlations coefficients between variations in price elasticity and change in prices, and income elasticity and change in income

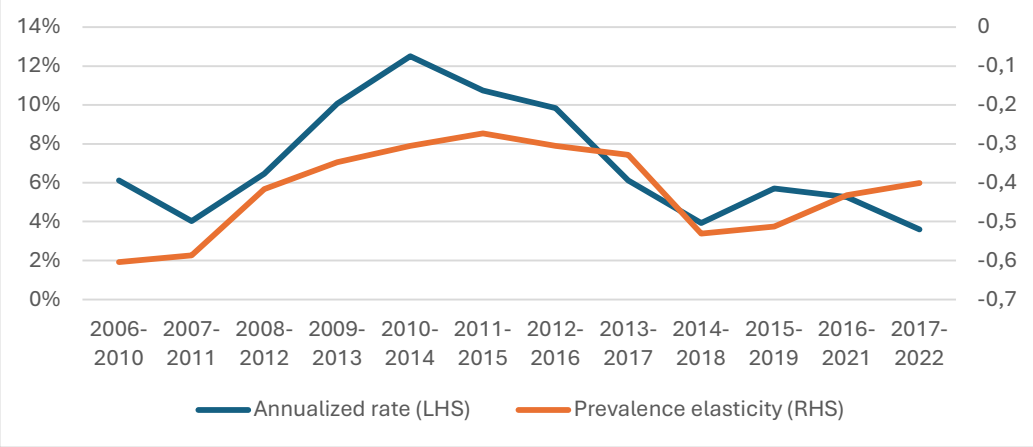
	Elasticity component	Log model		Level model	
		Change in prices	Change in income	Change in prices	Change in income
Total	Price	-0.51		-0.63	
	Income		0.85		0.88
Prevalence	Price	0.72		0.65	
	Income		0.83		0.87
Intensity	Price	-0.78		-0.78	
	Income		0.88		0.89

Source: own calculations

Note: Annualized subperiod rates of change in price/income

The correlation between prevalence elasticity and change in prices is positive, indicating that the higher the price change, the less price responsive is the prevalence as illustrated in Figure 9.

Figure 9. Correlation between prevalence elasticity (log model) and annualized changes in price

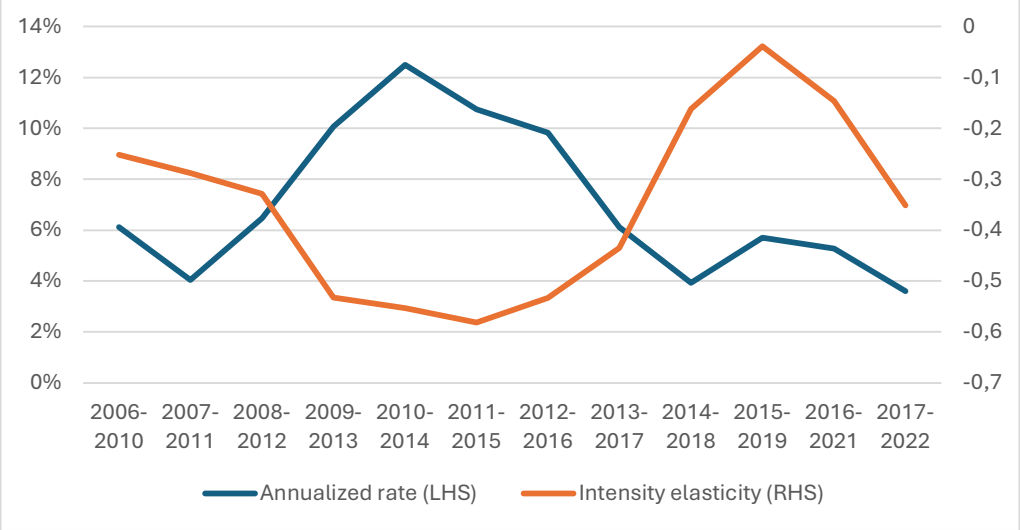


Source: own calculations

Note: Annualized subperiod rates of change in price

Conversely, intensity elasticity and price tends to move in opposite direction: the higher the price increase, the more responsive the demand in terms of smoking intensity (Figure 10). Overall, correlation between total elasticity and price is negative: the higher the price, the stronger the negative response of the demand to price indicating that variations in intensity component dominates variations in prevalence in the structure of variations in total elasticity. This is in line with the expectation that overall volatility of the sum of two random variables will be primarily driven by variations in variable that is more volatile, which in this case is intensity elasticity.

Figure 10. Correlation between intensity elasticity (log model) and annualized changes in price



Source: own calculations

Note: Annualized subperiod rates of change in price

The correlation analysis confirms that the variations in size of the elasticity are very likely associated with variations in size of price changes, in line with the previously mentioned study of Dautzenberg & Dautzenberg (2019). In addition, some of the mentioned studies on the elasticity of demand for energy come to the similar conclusion, that the higher increase in energy prices leads to the higher sensitivity of demand (Inglesi-Lotz, 2011; Mikayilov et al., 2020).

Research question 2: Does the price elasticity of smoking prevalence decline over time?

The second research question is closely related to the hardening hypothesis, which proposes that as smoking prevalence declines the proportion of "hardcore" smokers will increase. Subsequently, prevalence elasticity is expected to increase (decrease in absolute size), as smokers heavily addicted to nicotine got less responsive to the change in price or income. Figure 5 already indicates that despite volatility in size, no trend of increase in price prevalence elasticity is observed.

Nevertheless, we run formal tests to check if the latter finding can be statistically confirmed. To this end, we adopted an approach from Chern & Bouis (1988), who estimated if change in electricity prices caused structural changes in consumer behavior over time. The rationale of this approach is to split the sample on two non-overlapping subperiods, and then to roll subsample

regressions by moving year of split. Following their approach, we started from division total sample on two subperiods 2006-2010 and 2011-2022 and run regressions by moving year of split until 2006-2016 and 2017-2022 (to secure that each subperiod covers at least 5 years being a minimum for stable estimates as discussed before).

The results of the estimation presented in Table 7 do not indicate that some structural changes occur when the total period 2006-2022 is considered. By moving the splitting year toward more recent period, the prevalence elasticity estimate in the first subperiod indeed declines, but in the second subperiod it is quite stable and difference seems to be insignificant for each set of regressions apart from the first one.

Table 7: Price prevalence elasticity estimated, log model, non-overlapping subperiods

Subperiod I	Subperiod II	Subperiod I estimate	Subperiod II estimate	Difference	P-value
2006-2010	2011-2022	-0.6035	-0.3257	-0.2778	0.0342
2006-2011	2012-2022	-0.5634	-0.3441	-0.2194	0.1070
2006-2012	2013-2022	-0.4950	-0.3910	-0.1040	0.4641
2006-2013	2014-2022	-0.4111	-0.4387	0.0276	0.8375
2006-2014	2015-2022	-0.3728	-0.4398	0.0670	0.6186
2006-2015	2016-2022	-0.3100	-0.3261	0.0161	0.9204
2006-2016	2017-2022	-0.3031	-0.4003	0.0972	0.6313

Source: own calculations

The findings from Table 7 may at first sight look contradictory to the findings from Table 5, wherein difference between the highest and lowest price prevalence elasticity appears significant. Yet, it should be noted that both the highest and lowest estimates coming from the subperiod before 2016, so it is possible than in the first ten years some structural changes in smokers behavior regarding prevalence indeed happened, but over the longer run prevalence elasticity has stabilized, in favor of rejecting hardening hypotheses in line with other findings on the subject discussed in Literature Review section (Brennan et al., 2019; Kulik and Glantz, 2016).

Research question 3: Does the predictable dynamics and size of price changes affect the respective response of demand for cigarettes?

As previously mentioned, following the introduction of excise calendar that established a practice of semi-annual growth of specific excise predefined over the 5-year period, and industry has responded by constant semi-annual increase in retail price of 10 RSD (approximately 0.08 EUR) regardless of the growth in specific excise. Eventually it resulted in highly predictable dynamics and size of changes in retail prices since 2015 that can be clearly observed in Figure 1. Estimates of price elasticity presented in Table 4 and Figure 5 suggest that decline in price elasticity roughly corresponds to the period in which dynamics and size of changes in cigarette retail prices got highly predictable.

Therefore, it is legitimate to raise the question whether predictability in prices could have structural impact on demand for cigarettes. To examine this issue more deeply, we estimated price elasticities for subperiods 2006-2014 and 2015-2022 and test if there is a difference among estimates. The results are shown in Table 8. While the size of total price elasticity in the subperiod

of non-predictable increase in prices is indeed larger, there is no statistical evidence to support that this difference is significant. The estimated prevalence elasticity does not differ, as already indicated in Table 7. The most intriguing result is statistically significant difference of intensity elasticity at the 0.05 level – intensity of smoking seems to be two times higher in the first subperiod than in the subperiod of high pricing predictability. This is in line with findings from Table 4 that in three rolling subperiods covering period 2014-2021 estimated price intensity elasticity is not significant at all.

Table 8. Price elasticity estimated, log model, 2006-2014 vis-à-vis 2005-2022

	2006-2014	2015-2022	Difference	P-value
Total	-0.8339	-0.6837	-0.1502	0.3528
Prevalence	-0.3728	-0.4398	0.0670	0.6186
Intensity	-0.4609	-0.2471	-0.2138	0.0182

Source: own calculations

As underlined by Li et al. (2017), "*little is known about the impact of small, persistent, predictable tobacco tax increases on smoking behavior*." Therefore, we hypothesized that price elasticity of demand for cigarettes consists of certain basis level, which is common for all countries, and country-specific component that vary over time depending primary on the tobacco control measures and their implementation, but also on the stage of economic and social development. In this study, we actually examined if dynamics of country-specific component of elasticities is driven by two factors related to cigarette prices: one observable - magnitude in variation of prices, and one unobservable, - effects that predictability of cigarette pricing (since 2015) has on smokers' behavior. Additionally, we recognize that there are some other non-price factors that affect elasticity (such as changes in tobacco control legislation and changes in tightness of legislation implementation), but we were not able technically to include them in analysis regarding short time span of rolling windows. The latter can be illustrated in case of dummy advertising ban introduced in 2010 – it works on the level of total sample, yet, in subperiods starting from 2010 (for instance 2011-2015), it has no variations.

In the subperiod 2015-2022, we hypothesize that predictable increase in expenditures on cigarettes were gradually incorporated in the budget planning by the smoking households, through crowding out of some other goods and services (crowding-out effects of increasing tobacco expenditures in Serbia was empirically demonstrated by the study of Vladisavljević et al. (2024)). Therefore, intensity elasticity plunged to the level of statistical insignificance observed in subperiods 2014-2018, 2015-2019 and 2016-2021. Nevertheless, total elasticity did not fall so sharply due to recovery of the prevalence elasticity. While the latter is tricky to explain; it is likely the consequence of the smoking cessation by the certain fraction of smokers who were discouraged in the long run to keep smoking by substantial increase in prices over time.

Our findings on declining intensity elasticity and steady prevalence elasticity observed in the period of high predictability of increase in taxes and prices of cigarettes are comparable to findings of Li et al. (2017) that smokers did not significantly changed behavior following two small and predictable increases of excise in New Zealand, although overall cessation-related activity was before and after increase in taxation. Authors discuss two possible interpretations: one that smokers adapted to the regular small increases in tobacco price losing motivation to change

behavior, and second that persistent and predictable nature of the tax increases allows industry to implement strategies that dilute the impact of the tax increases on tobacco consumption (which in Serbian case would be unusual strategy of industry to increase prices in the fixed nominal amount of 10 RSD).

Eventually, intensity elasticity bounced back at the very end of the period analyzed, making in turn demand for cigarettes more elastic during the period 2017-2022. Nevertheless, it should be noted that the last two subperiods comprise the year 2020 in which HBS was not implemented due to Covid pandemic, which may influence the reliability of the estimates. Therefore, further extension of the analysis in the upcoming years is needed to figure out whether the increase in price elasticity in the subperiod 2017-2022 becomes a steady trend or is a consequence of some data distortion.

Eventually, we examine the robustness of our estimates by extending the model specification to include some additional variables that arguably affect demand for cigarettes. In particular, we use share of expenditures for alcohol and horeca (hotels, restaurants, coffee bars) in household budgets, following the findings from Vladisavljevic et al. (2024) that these groups of expenditures have "crowding-in" effect being positively associated with consumption of cigarettes. The results of additional estimation confirm positive impact on cigarette consumption (especially the impact of share of expenditures on alcohol on prevalence of smoking), but pattern of estimated elasticities over time does not substantially differ from this from baseline estimation.

7. CONCLUSIONS

In the last couple of decades, the number of studies estimating price and income elasticity of demand for tobacco have proliferated. Typically, such a study assumes that price elasticity is constant, then estimates price elasticity based on historical data, and projects a change in public revenues for an arbitrary change in price (imposed by an arbitrary change in taxation), regardless of the broader context of tobacco taxation practices of the policymakers and tobacco pricing practices of the industry.

In this study we have challenged the view that price elasticity of demand for cigarettes is constant by hypothesizing that broader changes in tobacco taxation and pricing practices may result in structural changes of demand for tobacco, which in turn leads to varying price elasticity. We examined the variations in elasticities of household demand for cigarettes using data from Serbian household budget surveys and found mixed evidence that price elasticity varied over the period 2006-2022. More specifically, we found that estimates of price prevalence and intensity elasticities were significantly different in some subperiods, but due to their co-movements in opposite directions, no evidence indicates that total elasticity changed over time. On the other hand, estimates of income elasticity strongly indicate that sensitivity of demand for cigarettes has increased over time. In addition, price elasticity appears to be considerably more volatile (relative to overall trend) than income elasticity. The latter holds not only for total price elasticity, but also for prevalence and intensity components of total price elasticity.

Furthermore, we focus on the more specific research questions whether variations in estimated price elasticities will match some expectations that we formed based on the stylized facts and

previous work, including associations with magnitude of change in prices, associations with retail pricing practices and compliance with hardening hypothesis. Our findings suggest a negative correlation between total price elasticity (in absolute value) and price change, which means that larger increase in price leads to the higher fall in demand for cigarettes (relative to small changes in price), being primarily driven by negative correlation between change in prices and price intensity elasticity. Examination of the patterns of variations in price prevalence elasticities suggest that at some points in time prevalence elasticity significantly varied, but declining trend is not confirmed, and hardening hypothesis has been rejected. The most intriguing finding from our research is that over the period in which dynamics and size changes in retail prices got very predictable, intensity elasticity substantially shrank to such a low level that statistical tests could not even reject that intensity of smoking reacts to change in price at all.

Based on the stylized facts, we hypothesized that higher magnitudes of change in prices lead to more elastic response of demand for cigarettes, while higher predictability of change in prices makes response of demand more inelastic. The unanticipated sharp increase in prices of cigarettes seem to shock smokers, whose intensity of smoking declines unproportionally higher relative to moderate increase in prices. On the other hand, anticipated changes in prices lead to predictable cigarette expenditures, which are most likely incorporated into the budget planning of smoking households through the crowding out of other goods and services. This in turn results in an exceptionally inelastic response of demand for cigarettes by the smoking households, especially in terms of intensity of smoking. Unfortunately, lack of previous research on the subject limits' possibilities of results interpretation and critical appraisal of our reasoning.

Subsequently, the main policy recommendation is that the government should avoid moderate and predictable increases in tobacco taxes, as they lead to high predictivity of increase in retail prices and eventually to ineffective outcomes in terms of reductions in demand for cigarettes. Serbia is currently running the policy of highly predictable and regular moderate changes in tobacco taxation, and the ineffectiveness of such policy become visible through recent stagnation in prevalence rate and smoking intensity.

The main limitation of the research was restriction of the rolling windows to 5-year subperiods, which was imposed by the fact that only 16 annual HBS were conducted in Serbia as of 2023. Although the number of observations is still considerable (around 25,000 on average per 5-year rolling window), subsample-wise estimates of elasticities are still likely to be less reliable relative to aggregate estimates utilizing total sample. The other limitations related to the sample include concerns coming from the fact that data from the Serbian HBS do not have longitudinal structure, so that variations in elasticities may come from the variations in the scope of the sample. Also, in 2020, HBS was not implemented, which may affect reliability of the elasticity estimates in the last two subperiods.

The main topic for the further research that has been raised by this study is association between predictability of cigarette prices and elasticity of demand for cigarettes, as we are not aware of any empirical work that deals with this subject. The other possible directions for the future research include estimates of time-varying income elasticities with respect to income components (earned and transferred income) found to be relevant by the literature, or to conduct

regional extension of the research to enrich diversity of government policies and practices in tobacco taxation comprised by analysis.

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APPENDIX

Table A1. Definition of variables

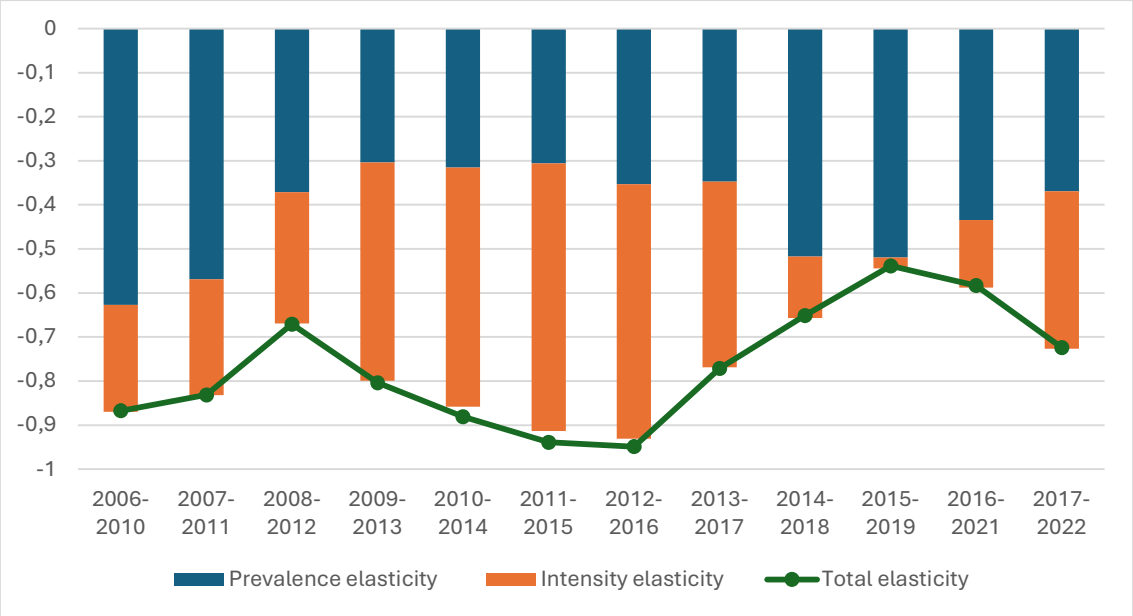
Variable	Description	Measure
Prevalence indicator	Equals one in case that household has positive expenditure on cigarette, zero otherwise.	Indicator
Number of cigarettes	Consumption of cigarettes by smoking household	Number of packs
Real cigarette price	Average unit cost of cigarette pack at the level of municipality (If at least three households reported cigarette expenditure within municipality) adjusted by overall HICP for the respective month in which household consumption was reported	Real RSD (2006=100)
Real monthly household income	Approximated by total monthly household expenditures adjusted by overall HICP for the respective month in which household consumption was reported	Real RSD (2006=100)
Household size	Total members of household	Number
Male ratio	Share of male household members	Percentage
Adult ratio	Share of household members older than 14 years	Percentage
Education	Maximum level of education achieved by household members, categorized as follows: Incomplete primary (less than 8 years of schooling), Primary (8 years), Secondary up to 3 years, Secondary 4 years, Tertiary 2 years, Tertiary 3+ years	Categories; referent - Incomplete primary
Region	Household location with respect to NUTS2 regional classification: Belgrade, Vojvodina, Sumadija and Western Serbia, Eastern and Southern Serbia.	Categories; referent - Belgrade
Activity status	Maximum level of activity achieved by household members, categorized as follows: Unemployed HH, Pensioner HH, Self-employed HH, Employed HH.	Categories; referent - Employed
Advertising ban	0 till 2009, 1 since 2010	Dummy

Table A2. Aggregate elasticities estimate 2006-2022, two-part model in levels

VARIABLES	Prevalence		Intensity	
	Coeff.	St. error	Coeff.	St. error
Real cigarette price	-0.005***	(0.001)	-0.004***	(0.000)
Real monthly household income	0.513***	(0.018)	0.225***	(0.015)
Real monthly household income squared	-0.029***	(0.001)	-0.011***	(0.001)
Household size	0.066***	(0.008)	0.036***	(0.003)
Male ratio	0.555***	(0.034)	0.167***	(0.016)
Adult ratio	0.528***	(0.062)	0.265***	(0.028)
Education (Referent - Incomplete primary)				
Primary	0.630***	(0.047)	0.037	(0.026)
Tertiary 2 years	0.742***	(0.047)	0.026	(0.024)
Secondary 4 years	0.494***	(0.048)	-0.060**	(0.026)
Tertiary 2 years	0.241***	(0.054)	-0.111***	(0.027)
Tertiary 3+ years	-0.061	(0.053)	-0.174***	(0.028)
Region (Referent – Belgrade region)				
Vojvodina	0.077*	(0.043)	0.069***	(0.025)
Sumadija and Western Serbia	0.327***	(0.044)	0.108***	(0.018)
Eastern and Southern Serbia	0.070	(0.045)	0.165***	(0.018)
Activity status (Referent – Employed)				
Unemployed HH	-0.013	(0.045)	0.037	(0.023)
Pensioner HH	-0.639***	(0.025)	0.001	(0.028)
Self-employed HH	-0.174***	(0.030)	-0.009	-0.012
Advertising ban	-0.208***	(0.045)	-0.062***	(0.016)
Constant	-2.394***	(0.104)	2.719***	(0.074)
Observations	86,736		86,736	

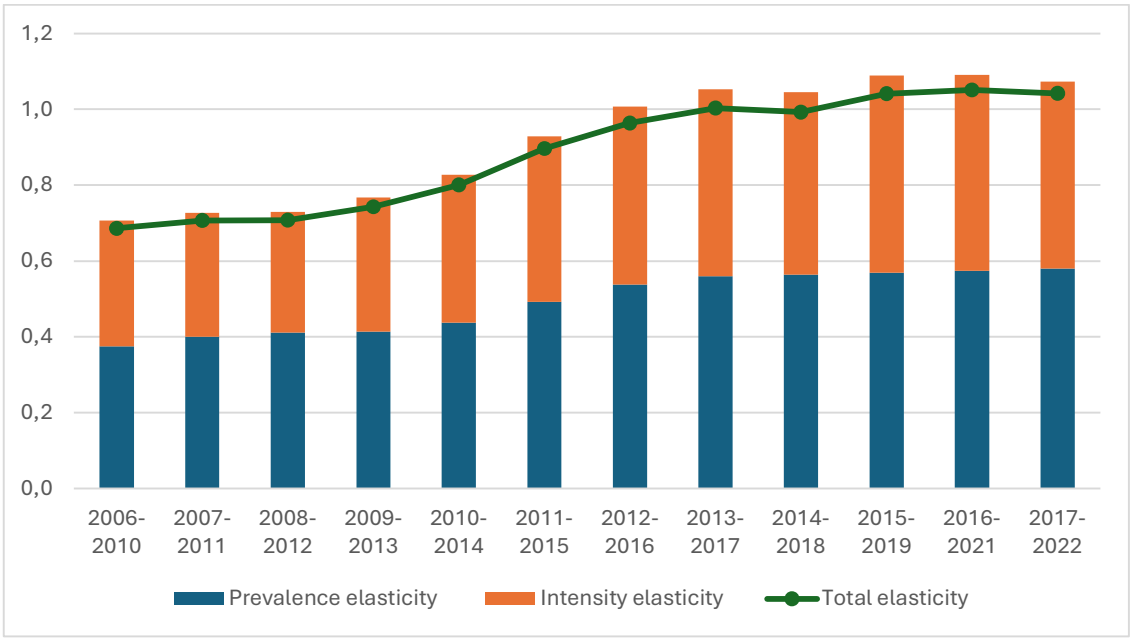
*Note: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1*

Figure A.1. Time-varying price elasticity of demand for cigarettes, level model



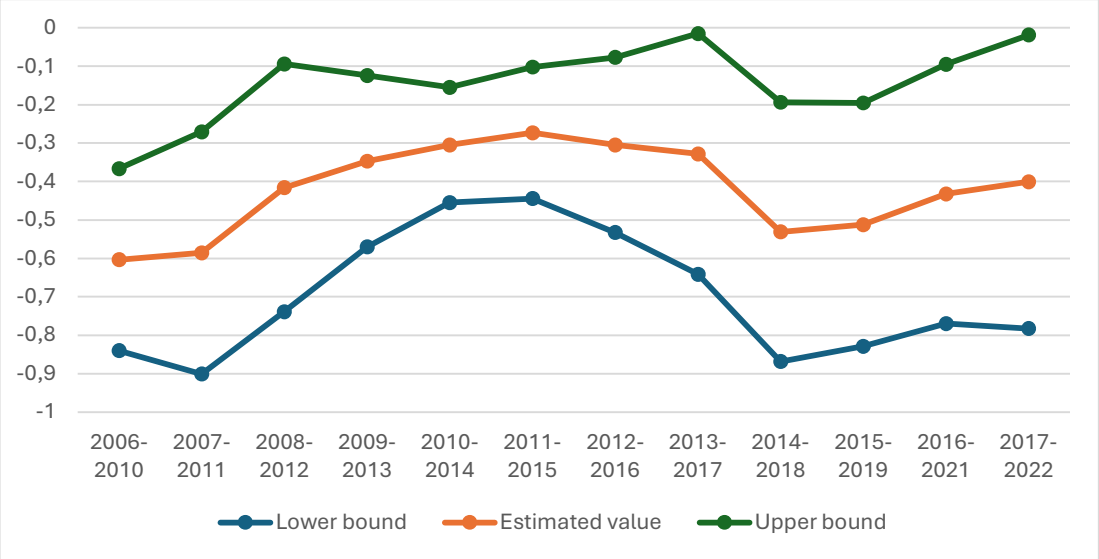
Source: own calculations based on HBS data

Figure A.2. Time-varying income elasticity of demand for cigarettes, level model



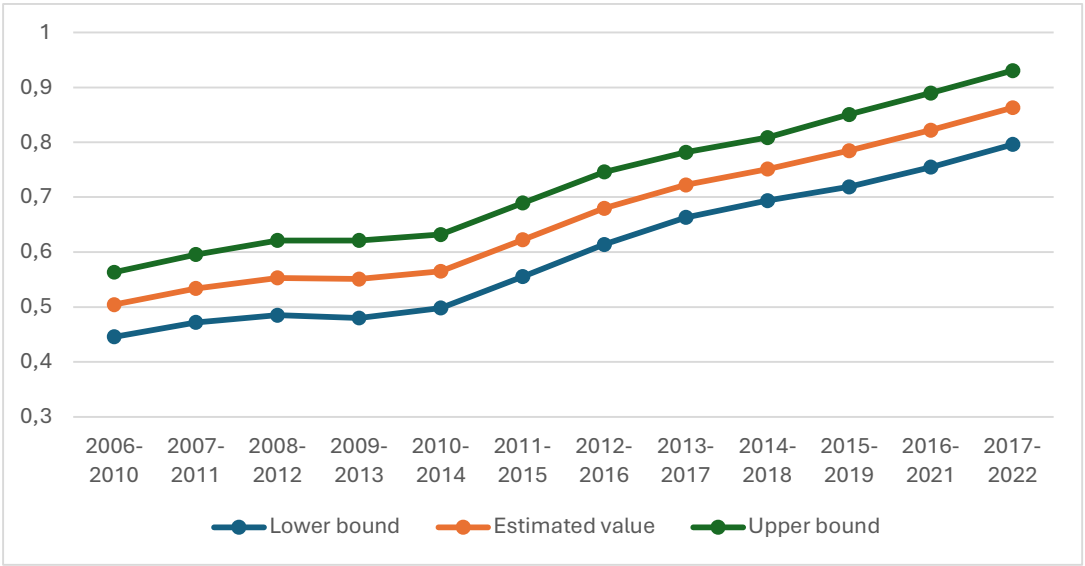
Source: own calculations based on HBS data

Figure A.3. Confidence intervals of the estimated price prevalence elasticities from the log model, rolling subperiods



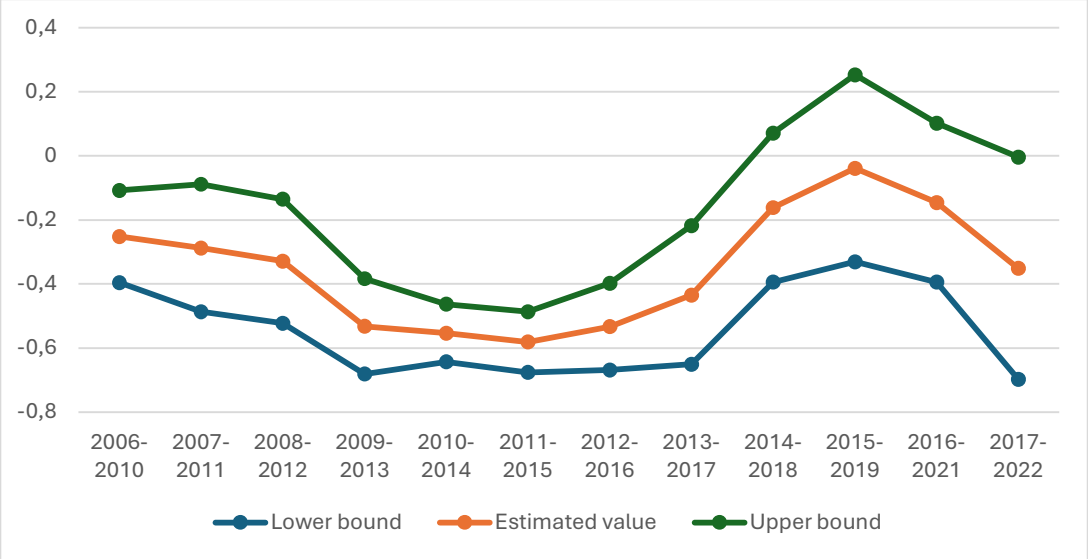
Source: own calculations based on HBS data

Figure A.4. Confidence intervals of the estimated income prevalence elasticities from the log model, rolling subperiods



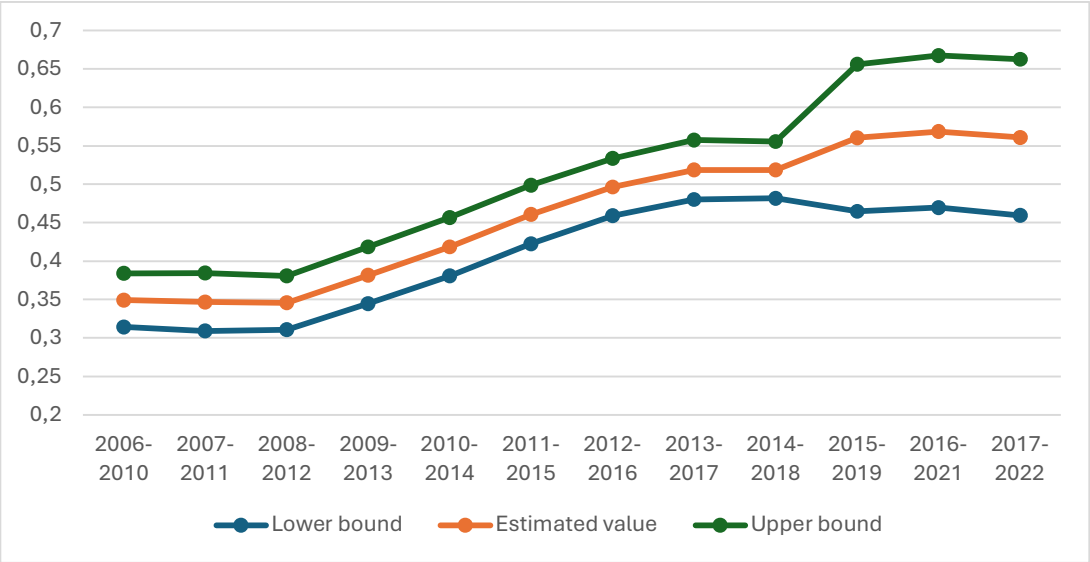
Source: own calculations based on HBS data

Figure A.5. Confidence intervals of the estimated price intensity elasticities from the log model, rolling subperiods



Source: own calculations based on HBS data

Figure A.6. Confidence intervals of the estimated income intensity elasticities from the log model, rolling subperiods



Source: own calculations based on HBS data