How Consumers Respond to Tobacco Price Changes: Evidence from Cigarettes and Heated Tobacco Products in Montenegro

Economics for Health Working Paper Series

Mirjana Čizmović,* Milica Kovačević,* Danijela Videkanić**

*** Faculty of Business and Economics, Mediterranean University, and Institute for Socio-Economic Analysis, Podgorica, Montenegro**

**** Institute for Socio-Economic Analysis, Podgorica, Montenegro**

November 2025

Paper No. 2026/11/1

Correspondence to: Mirjana Čizmović, mirjana.cizmovic@unimediteran.net

Suggested citation: Čizmović, M., Kovačević, M., & Videkanić, D. (2026). *How consumers respond to tobacco price changes: Evidence from cigarettes and heated tobacco products in Montenegro* (Economics for Health Working Paper No. 2026/11/1). ISEA. www.economicsforhealth.org/research/how-consumers-respond-to-tobacco-price-changes-evidence-from-cigarettes-and-heated-tobacco-products-in-montenegro-working-paper-series/

Acknowledgments: The Institute for Socio-Economic Analysis is funded by the Economics for Health team at Johns Hopkins Bloomberg School of Public Health to conduct economic research on tobacco taxation in Montenegro. EfH is a partner of the Bloomberg Philanthropies' Initiative to Reduce Tobacco Use (bloomberg.org). The views expressed in this document cannot be attributed to, nor can they be considered to represent, the views of Johns Hopkins or Bloomberg Philanthropies.

Abstract

Background

This paper examines consumer responses to price changes in Montenegro's tobacco market. Specifically, it estimates own-price and cross-price demand responses for cigarettes and heated tobacco products (HTPs), while accounting for product differentiation and shared manufacturer portfolios across categories. The analysis further considers market developments, tax changes, and relative price trends to place the estimated demand relationships in the context of a rapidly evolving tobacco market and to inform tobacco tax policy aimed at reducing overall tobacco consumption.

Methodology

Brand-level monthly administrative data from Montenegro's Tobacco Agency are analyzed for cigarettes and HTPs (2020–2025). Long-run own-price elasticities are estimated using a pooled mean group (PMG) panel error-correction model, with aggregate autoregressive distributed lag (ARDL) and instrumental-variable models as robustness checks. Cross-price substitution across four market segments (low-, medium-, and premium-price cigarettes and HTPs) is identified using a nested-logit demand model, estimated by two-stage least squares with excise taxes and product-characteristic instruments. The relationship between cigarette and HTP prices is examined through cointegration analysis, allowing for an endogenous structural break.

Results

Demand for both cigarettes and HTPs is price responsive in the long run, with HTPs substantially more elastic than cigarettes. The PMG own-price

elasticity for cigarettes is −0.79 and −1.40 for HTPs, with the nested-logit model yielding comparable estimates (−1.27 for HTPs and −0.70 to −0.84 across cigarette segments). All cross-price elasticities are positive, confirming that cigarettes and HTPs are economic substitutes, but substitution is asymmetric and concentrated within the cigarette market. At the aggregate level, a one-percent increase in cigarette prices raises HTP demand by approximately 0.71 percent, whereas a one-percent increase in HTP prices raises cigarette demand by only about 0.08 percent. Cigarette and HTP prices share a stable long-run equilibrium, with HTP prices adjusting towards cigarette prices following a structural break in mid-2022.

Conclusions

Cigarettes and HTPs function as moderate, asymmetric economic substitutes in Montenegro's tobacco market: higher cigarette prices generate measurable switching towards HTPs, while higher HTP prices prompt only limited switching to cigarettes. Because the two products share a common pricing equilibrium and are largely supplied by the same manufacturer, an excise policy that raises cigarette taxes without adequate increases in HTP taxes will partly divert consumption towards HTPs rather than reduce overall tobacco use. Coordinated, simultaneous taxation of both product categories is, therefore, needed to reduce aggregate tobacco consumption while limiting price-driven substitution.

JEL Codes: I18, H25, D12, L11, L66

Keywords: heated tobacco products, price elasticity, substitution patterns, tobacco taxation, cigarette demand

Introduction

Montenegro has pursued a sustained strategy of strengthening cigarette taxation, positioning excise policy as an important component of both fiscal and public health governance. This approach, characterized by a prolonged series of tax adjustments since 2010, has ensured full compliance with the European Union (EU) Tobacco Products Directive minimum excise requirements and World Health Organization (WHO) guidance on tax shares.

Although the prevailing EU minimum cigarette excise threshold was met by 2025 (with a specific excise of €53.50 per 1,000 cigarettes and an ad valorem of 24.5 percentage points of the retail price), the policy of regular increases has continued under the amended Law on Excise Tax, which has been in effect since January 2026. This legislation establishes a predefined semi-annual adjustment schedule extending through 2028, with the specific excise rising from €58.85 in early 2026 to €94.78 from July 2028 onward. Over this period, the reform implies an annual increase of around 21 percent in specific excise, and over the full implementation period the specific excise will increase by approximately 61 percent cumulatively. The ad valorem rate remains unchanged at 24.5 percent. In parallel, the Law defines the evolution of the minimum excise burden per 1,000 cigarettes, which will reach €105.16 by the end of 2026 and €130.26 by mid-2028, signaling a clear trajectory towards more stringent tobacco regulation.

While cigarette taxation has been tightened, the tobacco market has been significantly transformed by the emergence of heated tobacco products (HTPs), which have challenged conventional regulatory approaches globally (Campaign for Tobacco-Free Kids, 2023; López Nicolás, 2023; World Health Organization, 2021a, 2021b). In Montenegro, since their

market entry in late 2019, HTPs have been classified as smokeless tobacco, resulting in less-comprehensive regulation compared to cigarettes and an absence of bans on their use in enclosed public spaces. This regulatory environment has coincided with a sharp rise in consumption.

According to the Survey on Tobacco Consumption in Southeastern Europe in 2019 (STC-SEE) and in Montenegro in 2022 (STC-MNE), adult HTP prevalence rose from 0.2 percent in 2019 to 3.9 percent in 2022 (Mugosa et al., 2020; Čizmović et al., 2024). Furthermore, European School Survey Project on Alcohol and Other Drugs (ESPAD) data indicate a concerning trend among youth, with the use of HTPs surging from 2.5 percent to 13.12 percent[1] between 2019 and 2024 (ESPAD, 2024). By 2025, total HTP sales volume had increased ninefold compared to 2020 levels, capturing 14.46 percent of the legal cigarette market.

The market penetration of HTPs in Montenegro is characterized by specific user demographics and prevailing perceptions regarding product safety. According to STC-MNE, HTP users are predominantly urban, tertiary-educated young adults, particularly women, with higher-than-average household incomes, many of whom are current or former smokers of manufactured cigarettes. The increasing adoption of HTPs is accompanied by widespread misconceptions that these products represent a reduced-risk alternative, often reinforced by industry marketing strategies that may encourage dual-use patterns (Čizmović et al., 2024).

Despite substantial increases in HTP taxation, with the excise duty rising from €26.21/kg in 2020 to €190/kg for the 2024–2025 period, these products still maintain a notable tax advantage over cigarettes. Per pack, this represents an increase from €0.14 in 2020 to €1.01 in 2025, bringing

[1] Measured as a prevalence in the last year.

the HTP excise tax burden to approximately 31.5 percent of the retail weighted average price (WAP) of the HTP pack, compared to the 59-percent excise burden on a cigarette pack's WAP. Although the tax gap has narrowed from 57.2 percent in 2020 to 27.5 percent in 2025, the remaining differential continues to influence market dynamics.

Moreover, these dynamics are shaped by asymmetric fiscal transmission. Evidence of under-shifting of tax pass-through prices shows that a €1 increase in HTP taxes results in only a €0.26 increase in market prices, as manufacturers absorb most of the tax to keep HTPs competitive with mid-range and premium cigarettes. Notably, the indirect pass-through effect of cigarette taxes on HTP prices is estimated at 0.9, suggesting that cigarettes serve as a primary pricing reference and that HTP pricing is more sensitive to cigarette tax changes than to direct HTP taxation (Čizmović et al., 2024).

While market trends indicate a connection between traditional cigarettes and HTPs, their exact relationship remains unclear. Given the industry's strategic pricing and the rapid increase in HTP use, it is important to analyze these market dynamics using empirical data. The aim of this paper, therefore, is to examine how demand for cigarettes and HTPs responds to price changes in Montenegro's evolving tobacco market. The paper estimates own-price and cross-product responses, as well as the speed of adjustment to price changes, while accounting for product differentiation and the fact that cigarettes and HTPs are often supplied by the same manufacturers.

To provide context for these estimates, the paper also examines recent developments in the tobacco market, including changes in market shares, excise taxation, and relative prices between cigarettes and HTPs. This evidence is used to interpret observed substitution patterns and assess

the implications of tobacco taxation for reducing tobacco use. These results can inform a comprehensive fiscal strategy that considers market diversification and ensures that tax policies promote both revenue stability and public health, rather than treating cigarettes separately from other products.

1. Literature review

The economic foundation for tobacco taxation is rooted in corrective (also known as sin) tax theory, which holds that excise taxes serve as instruments to internalize negative externalities and behavioral internalities associated with consumption (O'Donoghue & Rabin, 2006; Farhi & Gabaix, 2020; Gruber & Kőszegi, 2004; Allcott & Rafkin, 2021). In a multi-product environment, the effectiveness of these taxes depends significantly on cross-price elasticity, which determines whether products function as substitutes or complements. While the literature on traditional tobacco products is well established, empirical evidence on HTP price sensitivity and the interaction between conventional cigarettes and HTPs remains limited. Existing studies generally fall into two categories: those using market-level data and those relying on individual-level survey data capturing consumers' smoking behavior and product use.

The available evidence on HTPs' own-price elasticity suggests relatively high price sensitivity of demand, although estimates vary by user profile. One of the most comprehensive cross-country analyses to date, covering more than 30 countries from 2014 to 2022 and using quarterly and annual data was done by Dauchy and Shang (2024). The study employed seemingly unrelated regression (SUR) models and found HTP demand to be highly elastic, meaning a 10-percent price increase could lead to a 12- to 13-percent drop in sales in the short term. This suggests that HTP

consumption is roughly four times more responsive to price changes than traditional cigarette consumption. Evidence on e-cigarettes, another emerging tobacco product, likewise indicates predominantly elastic demand, although the magnitude of estimated elasticities varies across product types and across the countries or regions analyzed (Cotti et al., 2022; Huang et al., 2014; Stoklosa et al., 2016; Saffer et al., 2020).

In contrast, Do et al. (2025) employed a volumetric choice experiment among adults in the United States of America, utilizing multilevel, zero-inflated, negative binomial models to capture the behavior of dual users. Their study reported a much more inelastic demand for HTP (-0.40), suggesting that users who already engage in dual use (HTPs with e-cigarettes or cigarettes) are significantly less likely to reduce consumption in response to price hikes. However, this estimate may also reflect methodological differences between stated-preference approaches, such as volumetric choice experiments, and revealed-preference studies based on actual sales or consumption data. Indeed, the latter generally tend to find HTP demand to be more price elastic.

Turning from own-price to cross-price elasticities, the emerging empirical literature begins to shed light on the interaction between HTPs and conventional cigarettes. Dauchy and Shang (2024) identify a positive but asymmetric substitution pattern, showing that HTP demand responds significantly to cigarette price changes, with estimated cross-price elasticities ranging from 1.63 to 1.99 across model specifications, while cigarette demand remains largely insensitive to HTP prices. Focusing on Italy, Marzioni et al. (2023) apply a Marshallian demand framework combined with cointegration analysis, rather than directly estimating cross-price elasticity coefficients. Their results indicate that HTPs and cigarettes are strong economic substitutes and share a stable long-run

equilibrium, implying that they operate within an integrated tobacco market rather than as separate product categories. The heterogeneity across those findings likely reflects differences in market maturity and regulatory design among the countries studied.

A similarly inconclusive pattern is observed in studies examining cross-price relationships between cigarettes and e-cigarettes, providing a useful point of comparison with the HTP literature. Most studies identify partial substitutability between the products, with e-cigarettes responsive to cigarette price changes (World Health Organization, 2021b), although some report substitution in the other direction (Cotti et al., 2022; Saffer et al., 2020) as well as statistically nonsignificant relationships, particularly when accounting for dual use and heterogeneous consumption behavior (Cheng et al., 2019).

The literature further points to a divergence between market-level evidence and individual-level survey findings regarding the relationship between HTPs and cigarettes. While studies relying on aggregate market data generally identify some form of substitution effects, survey-based evidence from South Korea suggests complementarity between HTPs and cigarettes in actual product use. Hwang et al. (2019) analyzed the 2018 Korea Community Health Survey using multinomial logistic regression and found that 96.25 percent of HTP users were dual users, suggesting that exclusive HTP use remained relatively uncommon. Similarly, Lee et al. (2024) utilized the International Tobacco Control (ITC) Korea Survey, revealing that 59.6 percent of HTP users also smoked cigarettes, with 86.6 percent of those dual users smoking cigarettes daily. This evidence from survey-based analyses suggests that HTPs may complement, rather than substitute for, conventional cigarette use.

The demand relationship between HTPs and conventional cigarettes remains an open empirical question. By providing new evidence on how demand for HTPs relates to cigarettes, this study adds to the limited existing research and helps clarify their fiscal relationship and the implications for tobacco tax policies.

2. Data

2.1 Data sources and market coverage

This research uses monthly data on brand-level retail prices and quantities of cigarettes and HTPs sold per pack from 2020 to 2025. The data, sourced from the Directorate for Issuing Permits for the Production, Processing, and Trade of Tobacco Products (Tobacco Agency), cover only imported brands sold in standard 20-cigarette packs, as there is no domestic production.

Between 2020 and 2022, the number of active cigarette brands stabilized at roughly 80–100, and by the end of 2025 the market included 78 active brands. Although many brands remain present throughout their observed period, some temporarily exit and later re-enter the market. On average, brands experience approximately one interruption in market presence, with gaps lasting about six months. The dynamics of brand entries and exits over time are illustrated in Annex A (figures A1 and A2).

Products are classified into three market segments: economy-price, middle-price, and premium cigarettes. Cigarette brands are grouped into price segments using a market-based classification that combines observed retail prices with information from industry and importer sources, following methods used in previous similar research (Čizmović et al., 2026; Tauras et al., 2006). By 2024, the Montenegrin tobacco market

was supplied by three importers representing four major international tobacco manufacturers.[2]

The HTP dataset comprises an unbalanced panel of 1,309 brand–month observations across 40 brands for up to 72 months (2020–2025). The number of active brands rose from 8 in 2020 to 17 in 2022, reflecting the HTP market's early expansion. Market dynamics intensified after 2023, with successive waves of product entry bringing the number of brands to 31 in 2024. Although some brands exited thereafter, the total remained unchanged by the end of 2025.

Compared with cigarettes, brand presence in the HTP segment is more continuous, with roughly one gap per brand on average and interruptions typically lasting about two months. Monthly entry and exit dynamics for HTP brands are presented in Annex A (Figure A3). The HTP category is dominated by a single manufacturer that also has a substantial presence in the cigarette market. This overlap is incorporated into the empirical analysis because products supplied by the same firm may exhibit demand relationships that differ from those observed between products offered by competing manufacturers.

Table 1 reports descriptive statistics for cigarette and HTP nominal prices and brand-level monthly sales. Price statistics are weighted by the number of packs sold. Over the observed period, cigarette prices range from €1.80 to €5.50 per pack. Half of all packs were sold at prices below €2.80, while the middle 50 percent of sales occurred between €2.60 and €3.20. HTP prices display considerably less variation. The median price equals €3.00

[2] Philip Morris International brands (28 percent), followed by Japan Tobacco International (24 percent) and Karelia Tobacco Company (21 percent), with British American Tobacco ranking next (20 percent).

per pack, and most observations fall within a narrow €2.80–€3.20 range. Overall prices vary from €2.50 to €3.20, reflecting the more standardized pricing structure of this product category.

Sales are assessed at the brand–month level and show substantial variation for both product types. For cigarettes, the median monthly sales per brand is 26,450 packs, while the mean is 48,457 packs, indicating a strongly right-skewed distribution in which a small number of brands account for disproportionately large sales volumes. In comparison, HTP sales are lower but highly dispersed: the median monthly sales per brand is 8,710 packs, while the mean reaches 25,166 packs, with half of the observations recording monthly sales between 2,460 and 37,080 packs.

Table 1. Descriptive statistics of cigarette prices and brand-level sales (2020–2025)

Variable	Obs.	Mean	Median	Std. dev.	p25	p75	Min	Max
Cigarettes								
Price per pack (€)	6,295	2.92	2.80	0.53	2.60	3.20	1.80	5.50
Number of packs sold	6,295	48,457	26,450	71,128.70	8,170	59,680	11	1,121,767
HTP								
Price per pack (€)	1,309	3.00	3.00	0.19	2.80	3.20	2.50	3.20
Number of packs sold	1,309	25,166	8,710	33,177.90	2,460	37,080	9	189,311

Source: Authors' own calculations

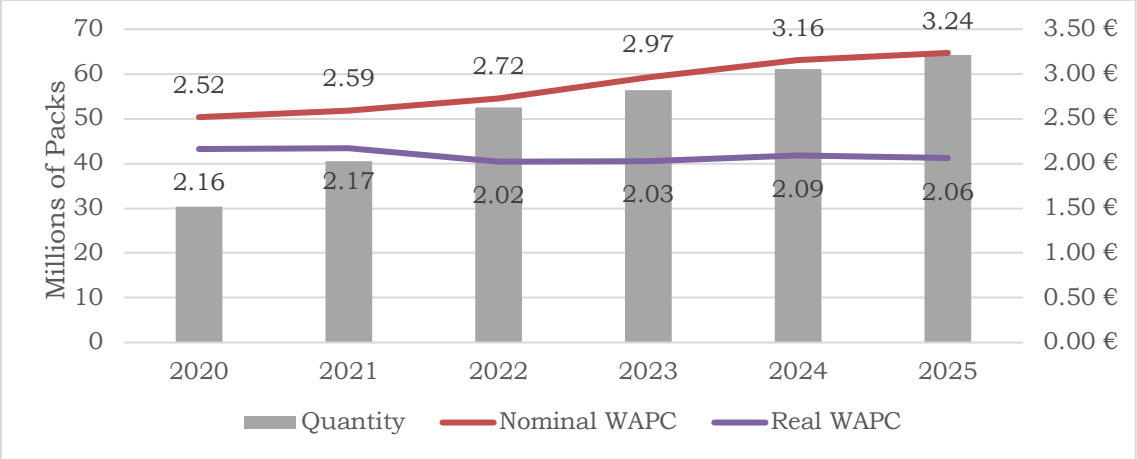
Notes: Price statistics are weighted by the number of cigarette/HTP packs sold. Sales statistics are reported at the brand–month level.

2.2 Market developments and pricing trends

To provide additional insight into annual trends, Figure 1 presents cigarette pack sales together with nominal and real weighted average price per pack of cigarettes (WAPC) in Montenegro from 2020 to 2025. Since 2020, legal cigarette sales have increased, reflecting the influence of rising incomes and inflation, which together contributed to higher affordability, as well as a decline in illicit trade following strengthened enforcement and regulatory reforms (Čizmović et al., 2024; Economics for Health (formerly Tobacconomics), 2023). Nevertheless, further reductions in the illicit cigarette market are expected to generate positive public health outcomes, as lower availability of illicit products raises the average price paid by smokers and thereby contributes to a reduction in overall tobacco consumption - legal and illegal (Joossens et al., 2010).

Despite continuous increases, nominal cigarette prices in Montenegro remain substantially below the European Union (EU) average: the WAPC in Montenegro was €3.23, compared with €6.51 in the EU (Euromonitor International, 2025). The price of the most-sold cigarette brand increased from €2.4 in 2020 to €3.2 in 2025 in nominal terms. However, after adjusting for inflation, the real price declined slightly. A similar pattern is observed for both the premium and cheapest cigarette brands, where real prices either slightly decreased or remained broadly unchanged over the observed period (Table A1 in Annex A).

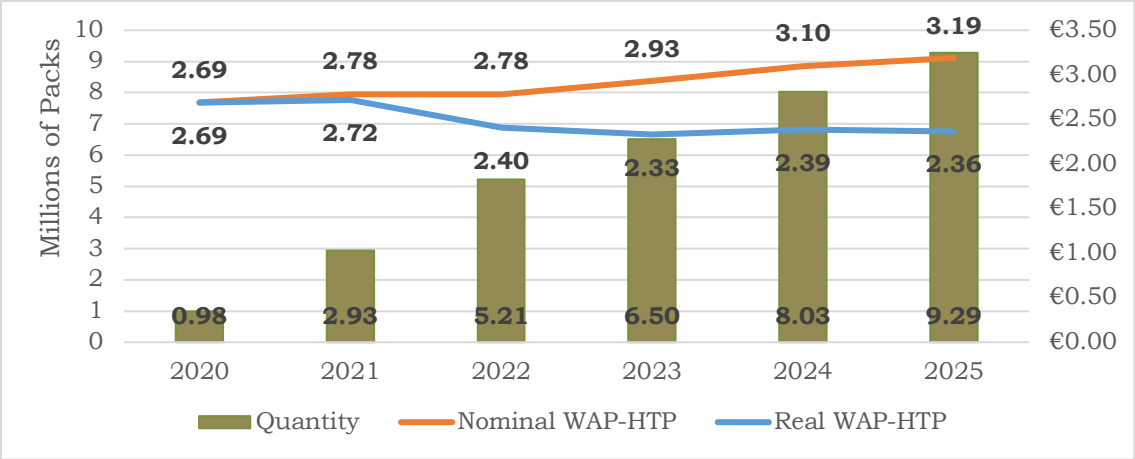
Figure 1. Annual cigarettes sold by pack and WAPC (2010–2025)



Source: Ministry of Finance Directorate for Issuing Permits for the Production, Processing, and Trade of Tobacco Products.
Note: WAPC is calculated using the quantity of cigarette packs sold per brand as weights. Real WAPC is obtained by deflating nominal WAPC using the consumer price index (2010 = 100).

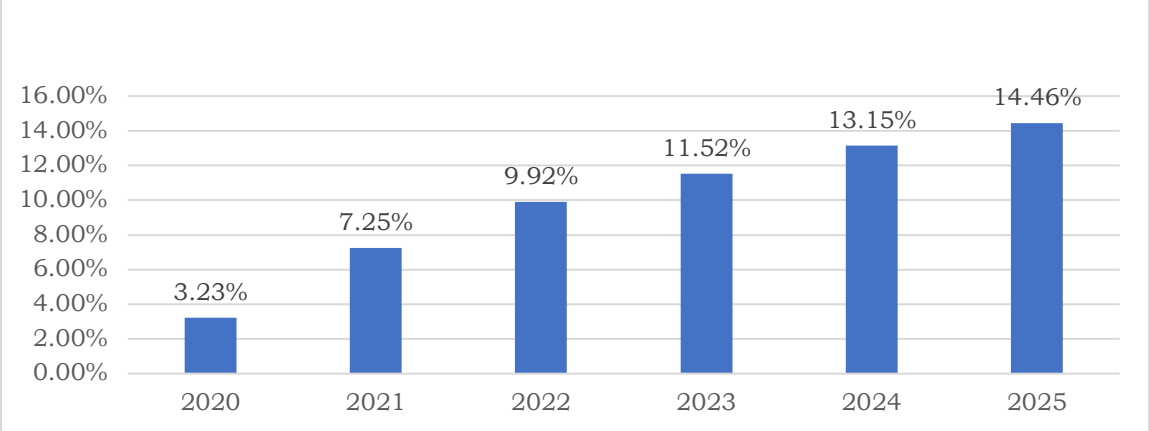
Figure 2a shows that the number of HTP packs sold increased rapidly over the observed period, rising ninefold from 2020 to 2025 (though from a very low baseline). Over the same period, the nominal WAPC increased gradually, while the real WAPC remained broadly stable after a moderate decline in 2022, suggesting that nominal price growth largely reflects general inflationary pressures. The share of HTP packs in the legal cigarette market increased steadily from 3.23 percent in 2020 to 14.46 percent in 2025, indicating the growing presence of HTP products in the tobacco market during the period under analysis (Figure 2b).

Figure 2a. Annual HTP sold per pack and WAP-HTP (2020–2025)



Source: Ministry of Finance Directorate for Issuing Permits for the Production, Processing, and Trade of Tobacco Products.
Note: WAP-HTP is calculated using the quantity of HTP packs sold per brand as weights. Real WAP-HTP is obtained by deflating nominal WAP-HTP using the Consumer Price Index (2020 = 100).

Figure 2b. Share of HTP sales in the legal cigarette market (2020–2025)



Source: Ministry of Finance Directorate for Issuing Permits for the Production, Processing, and Trade of Tobacco Products.

Monthly cigarette and HTP sales exhibit clear seasonal variation, with peaks typically occurring in June, July, August, and December. Figures

A4 and A5 in Annex A illustrate this pattern using monthly pack sales for the observed periods. To account for such systematic within-year fluctuations in consumption, the empirical analysis includes a seasonal dummy variable and time-fixed effects.

The panel specifications also use controls for key institutional and market changes through dummy variables. The dummy reflects the July 2021 policy measure banning cigarette storage in the Port of Bar's free-trade zone, which contributed to a sharp decline in illicit trade (Economics for Health (formerly Tobacconomics), 2023). In addition, monthly time effects and brand-fixed effects are included to account for unobserved variation over time and across cigarette brands.

Control variables, including the monthly average wage and the consumer price index, are obtained from the Statistical Office of Montenegro (more details are provided in Table A2 in Annex A).

To express legal cigarette and HTP sales relative to the total tobacco market, the analysis incorporates an outside option representing tobacco consumption not captured by observed legal sales. The outside option primarily reflects illicit cigarette consumption and the use of other tobacco products. More details about the construction of the outside goods are given in the Methodology section.

The dataset also includes information on excise taxes, product characteristics, manufacturers, and market structure, which are subsequently used to construct instrumental variables. The main inputs are the specific excise tax for cigarettes and the HTP excise tax per pack. Table A3 in Annex A reports the cigarette and HTP excise tax calendar for 2020–2025, together with the newly adopted cigarette excise schedule for 2026–2028.

3. Methodology

The empirical analysis proceeds in three stages. The first stage examines the long-run pricing relationship between cigarettes and HTPs using cointegration methods that account for the structural market transition Montenegro experienced between 2020 and 2022. The second stage estimates own-price demand responses at the product level using panel error-correction models and validates them against aggregate time-series and instrumental-variable specifications. The third stage, representing the analytical core of the study, estimates cross-price substitution between cigarettes and HTPs using a structural discrete-choice demand model (nested logit) that accommodates product differentiation, market segmentation, and potential interactions among firms that simultaneously supply cigarettes and HTPs. Full technical details, including estimating equations, instrument construction, and robustness scenarios, are provided in Annex A.

3.1 Price dynamics and long-run cointegration

Before estimating demand responses, the long-run relationship between cigarette and HTP retail prices is characterized using time-series methods applied to monthly aggregate prices from January 2020 to December 2025. Unit-root tests that allow for an endogenous structural break (specifically the Zivot and Andrews (1992) test) are applied to each price series, given the pronounced structural shift in Montenegro's tobacco market as illicit-trade enforcement intensified and the legal market expanded (see Annex A for more details). The existence of a long-run pricing relationship between the two categories is assessed using the Johansen (1988) maximum-likelihood cointegration procedure and the Pesaran, Shin, and Smith bounds test (Pesaran et al., 2001), which remains valid under mixed orders

of integration. A confirmed cointegrating relationship indicates that the two product categories are embedded in a common pricing equilibrium. This motivates the cross-sectional identification strategy adopted in Section 3.3.

3.2 Own-price demand responses

Own-price elasticities for cigarettes and HTPs are estimated using the pooled mean group (PMG) estimator (Pesaran et al., 1999), applied to separate monthly panels of cigarette brands and HTP products. The PMG framework accommodates variables integrated of mixed order and imposes a common long-run price elasticity within each product category while permitting heterogeneous short-run dynamics across brands. The estimating equation relates log monthly sales to log real retail price, controlling for real net wages, monthly seasonality, and a time trend, specified in error-correction form (Annex B.2, Equation B1). The error-correction coefficient measures the speed of return to equilibrium following a price shock; its half-life is reported alongside the long-run elasticity.

Two robustness checks are estimated. First, aggregate autoregressive distributed lag (ARDL) models are estimated for each category using market-level data, with long-run relationships assessed via bounds testing; residual diagnostics include tests for serial correlation, heteroskedasticity, and parameter stability. Second, instrumental-variable regressions address potential price endogeneity, using statutory excise tax rates as instruments (the specific and minimum excise for cigarettes, and the excise per pack for HTPs). More details are given in Annex B.2.

3.3 Cross-price substitution: Nested-logit demand model

3.3.1 Identification strategy

Estimating cross-price effects between cigarettes and HTPs from time-series data is not feasible in the Montenegrin context: the two aggregate price series are highly correlated ($r \approx 0.85$) due to common excise shocks and shared macroeconomic dynamics, and empirical testing of ARDL cross-price specifications produces coefficients that are numerically unstable, changing the sign across otherwise equivalent specifications (Annex B.3). Cross-product substitution is therefore identified using a nested-logit demand model estimated via two-stage least squares (S. Berry et al., 1995; S. T. Berry, 1994; Nevo, 2000; Olesiński, 2020). This approach draws identification from cross-sectional variation in prices and market shares across approximately 123 brands observed each month — variation not dominated by aggregate time trends that confound dynamic panel estimators.

3.3.2 Model structure

The model treats each consumer's tobacco choice as hierarchical, with four market segments serving as nests: three cigarette segments (economy-price, middle-price, and premium) and HTPs. This structure allows substitution to be stronger within segments than across them, relaxing the independence-of-irrelevant-alternatives restriction[3] of standard logit. The estimated nesting parameter $\sigma \in (0, 1)$ governs within-segment

[3] This assumption implies that the relative odds of choosing between two products remain unaffected by the presence or characteristics of other products, which is an unrealistic assumption in markets like cigarettes. For example, if a low-priced brand is removed from the market, consumers are more likely to substitute for another low-priced brand than for a premium one, violating Independence of Irrelevant Alternatives (IIA) assumption (Vincent, 2015).

substitutability and is directly interpretable as a measure of market segmentation.

Mean utility is modeled as a function of real retail price, observable product characteristics (color, which signals perceived cigarette strength, especially when explicit strength labeling is not provided; format (long, slim; flavor; HTP variant; and device indicators), segment fixed effects, and market-month fixed effects. The model incorporates a manufacturer portfolio effect: the sole firm in Montenegro that simultaneously markets both cigarette and HTP brands is identified in the data, and its products are assigned a distinct price-sensitivity parameter that reflects potential differences in joint pricing strategy across the two categories. The estimating equation is the Berry (1994) linearization of the nested-logit share system, estimated using 2SLS with market-clustered standard errors (see Annex B.3 and Equation B5 for more details).

3.3.3 Market definition and outside good

Because Montenegro experienced substantial illicit tobacco trade, accounting for approximately 51 percent of total cigarette consumption in early 2020, legal sales alone cannot define the market. Using only legal sales would cause the subsequent formalization of the market to appear as genuine demand growth, biasing the estimated price coefficients. Total market size is therefore constructed by scaling observed legal cigarette sales upward to account for estimated illicit consumption, and the outside good captures all tobacco demand not attributable to observed legal products. The baseline trajectory of illicit market share follows a three-phase path estimated from survey data (STC-SEE and STC-MNE), and three alternative scenarios are estimated as robustness checks (Annex B.3.4).

3.3.4 Instrumental variables

Price, the price-manufacturer portfolio dummy interaction, and the within-nest share are treated as endogenous and instrumented using three groups: (i) statutory excise tax rates — cigarette-specific excise, minimum cigarette excise, and HTP excise per pack; (ii) Berry–Levinsohn–Pakes (BLP)-style product-count instruments constructed from the number of own-firm and rival products in the market and within each nest (S. Berry et al., 1995); and (iii) rival-characteristic instruments derived from observable attributes of competing brands (Gandhi & Houde, 2019). Because the price-manufacturer portfolio interaction is endogenous, all excluded instruments are additionally interacted with the portfolio dummy indicator. Four instrument combinations are estimated. Robustness of the identification strategy is assessed by estimating alternative specifications with different instrument combinations.

3.3.5 Elasticity computation

Own- and cross-price elasticities are computed via counterfactual simulation: prices of all products in a given segment are simultaneously increased by one percent, and new market shares are simulated using the estimated nested-logit share equations. The procedure yields a 4×4 matrix of segment-level elasticities; aggregate cigarette-HTP elasticities are obtained by simultaneously shifting all three cigarette-segment prices. Standard errors are computed using the delta method (Annex B.3.5, Equations B7–B8).

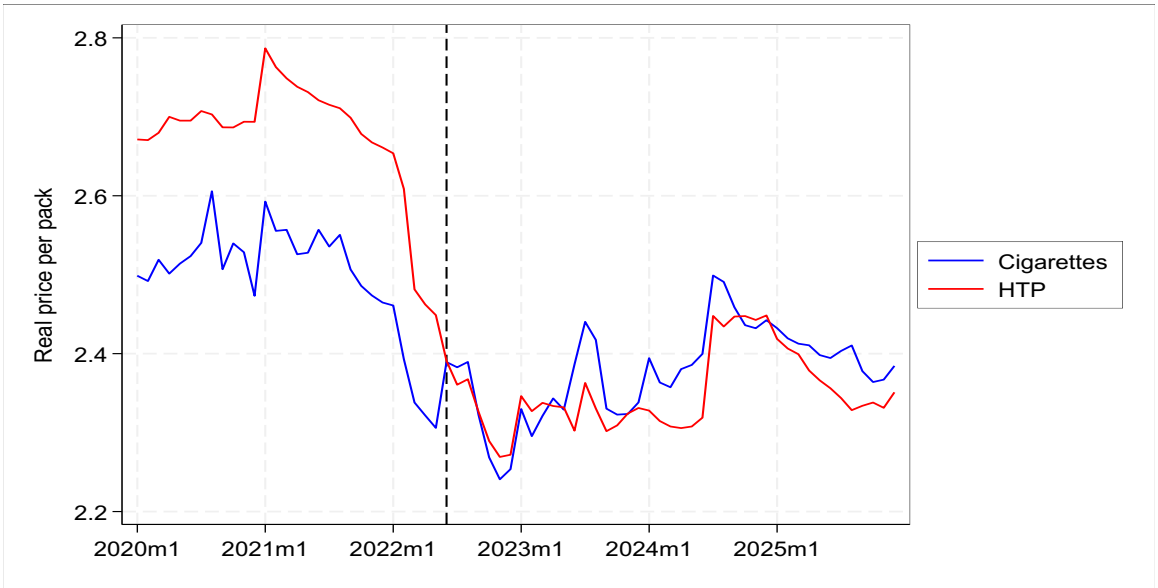
4. Results

4.1 Relative price dynamics

Since switching between products depends not only on absolute prices but also on the price relationship across product categories, examining the dynamics of cigarette and HTP prices is essential for interpreting subsequent elasticity estimates and understanding consumer responses.

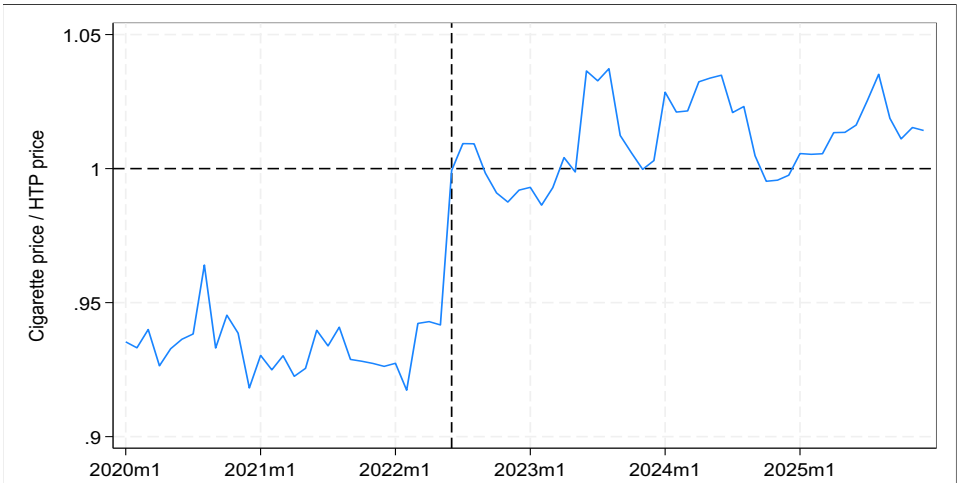
Figure 3a shows that HTPs were initially more expensive than cigarettes, but the price gap narrowed steadily over time, reaching near price parity by mid-2022. Thereafter, the relative price ratio fluctuated around one, with cigarettes occasionally becoming more expensive than HTPs (Figure 3b).

Figure 3a. Real WAPC of cigarettes and HTP



Source: Ministry of Finance Directorate for Issuing Permits for the Production, Processing, and Trade of Tobacco Products.

Figure 3b. Relative real price



Source: Ministry of Finance Directorate for Issuing Permits for the Production, Processing, and Trade of Tobacco Products.

To formally examine the relationship between the two-price series, their time-series properties are first assessed. HEGY tests indicate that real cigarette and HTP prices—and their relative price ratio—are non-stationary in levels, while the Zivot–Andrews test identifies a significant structural break in June 2022 (tables B1 and B2 in the Annex). Johansen cointegration and ARDL bounds tests further confirm the existence of a stable long-run relationship between cigarette and HTP prices despite changes in taxation and market conditions (tables B3 and B4 in the Annex). Additional vector error-correction (VECM) estimates reported in Table B3 suggest that deviations from the long-run equilibrium are corrected primarily through adjustments in HTP prices, while cigarette prices appear weakly exogenous.

Table 2 reports the ARDL estimates of this relationship. The baseline specification indicates a strong long-run association between cigarette and HTP prices. The significant interaction and post-break coefficients in the

extended specification suggest that the two-price series continued to move together after 2022, although around a different long-run equilibrium following the acceleration of HTP tax increases. The negative and statistically significant error-correction terms confirm that deviations from the long-run relationship are gradually eliminated over time. Approximately 12 percent of the disequilibrium is corrected each month under the baseline specification, increasing to 19 percent under the structural-break model, implying faster adjustment of HTP prices after 2022. The relatively small magnitude of the coefficients indicates that changes in relative prices occur gradually rather than immediately.

Table 2. ARDL estimates of the relationship between cigarette and HTP prices

Variable	**Baseline ARDL**	**Structural-break ARDL**
Error-correction term	-0.116*** (0.035)	-0.187*** (0.057)
Long-run effects		
Cigarette price	1.972*** (0.311)	2.288*** (0.440)
Cigarette price × post-2022	—	-1.392*** (0.523)
Illicit dummy	—	1.209** (0.472)
Short-run effects		
Δ Cigarette price	0.303*** (0.089)	—
Δ Cigarette price × post-2022	—	0.455*** (0.118)
Δ Illicit dummy	—	-0.382*** (0.098)
Constant	-0.099*** (0.036)	-0.212*** (0.046)

Notes: Standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.10.

The close co-movement between cigarette and HTP prices is consistent with the same firm operating in both product categories. This feature was

incorporated into the nested-logit specification by allowing price responsiveness to differ for products supplied by firms active in both markets. A full structural supply model could not be estimated because information on product-level marginal costs and wholesale prices was unavailable.

4.2 Own-price elasticities and adjustment dynamics

Before estimating own-price elasticities, the time-series properties of the panel data are examined. Panel unit-root tests indicate a mixture of stationary and non-stationary variables, which supports the use of the PMG estimator (Annex B, Table B5)

The results in Table 3 indicate statistically significant long-run own-price responses for both product categories. The estimated long-run own-price elasticity is −0.79 for cigarettes and −1.40 for HTPs, suggesting that HTP demand is substantially more responsive to price changes than cigarette demand. Real wages are positively associated with demand in both models, with a stronger income effect observed for HTPs. The short-run price coefficients are statistically insignificant in both specifications—as expected given the monthly frequency of the data—suggesting that behavioral responses to price changes occur gradually rather than immediately.

Table 3. PMG estimates of own-price demand responses

Variable	**Cigarettes**	**HTPs**
Long-run effects		
Real price	-0.787*** (0.145)	-1.398*** (0.274)
Real net wages	0.451*** (0.051)	1.839*** (0.363)
Adjustment dynamics		
Error-correction term	-0.658*** (0.046)	-0.323*** (0.070)
Model statistics		
Observations	5,824	947
Products	99	24
Log-likelihood	-297.14	221.61

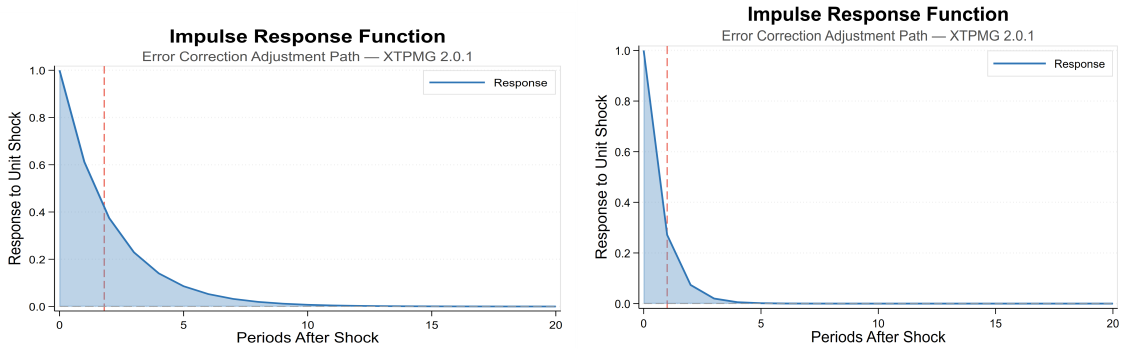
Source: Authors' own calculations

Notes: Standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.10. Error-correction coefficients measure the proportion of disequilibrium corrected within one month.

The estimated error-correction terms are negative and significant, confirming the existence of a stable long-run equilibrium relationship among demand, prices, and wages. Following a deviation from equilibrium, cigarette demand returns to its long-run path considerably faster than HTP demand (Figure 4), consistent with the larger error-correction coefficient estimated for cigarettes. The half-life of adjustment is approximately 0.95 months for cigarettes and 1.79 months for HTPs, indicating faster convergence towards equilibrium in the cigarette market.[4]

[4] The half-life represents the time needed for half of a temporary deviation from equilibrium to disappear. These estimates suggest that price adjustments occur within roughly one month for cigarettes and two months for HTPs.

Figure 4. Speed of adjustment following a cigarette (left figure) and HTP price shock (right figure)



Source: Authors' own calculations
Note: The figure reports the estimated impulse-response paths implied by the PMG error-correction models.

Overall, the results indicate that demand for both cigarettes and HTPs is price responsive in the long run, with HTP consumers exhibiting greater price sensitivity but slower adjustment towards equilibrium.

Aggregate ARDL and instrumental-variable (IV) models are estimated as robustness checks of the PMG results. The results of aggregate estimates closely align with the PMG findings (Annex B, Table B7), with slightly higher elasticities reflecting small-sample bias. Diagnostic and specification tests reported in Annex B (tables B6 and B8) support the aggregate specifications and the robustness of the main findings.

4.3 Nested-logit demand estimates and substitution patterns

The nested-logit estimates provide evidence on how consumers reallocate demand across cigarette segments and HTPs when relative prices change. As shown in Table 4, the estimated nesting parameter ($\sigma = 0.915$) indicates substantial within-group substitution, confirming the suitability of the

nested-logit framework. The interaction between price and the indicator identifying firms that supply both cigarettes and HTPs suggests that price sensitivity differs across products marketed by manufacturers operating in both product categories. Because prices and within-group shares are potentially endogenous, the baseline utility specification is estimated using instrumental variables. First-stage diagnostics indicate strong relationships between the excluded instruments and the endogenous regressors (Annex B, Table B9). The estimated coefficients also remain stable across alternative instrumental-variable specifications (Annex B, Table B10), supporting the robustness of the demand estimates.

Table 4. Baseline nested-logit demand estimates (utility function)

Variable	**Coefficient (SE)**
Price	-0.473*** (0.147)
Price × Firm supplies both cigarettes and HTPs	-0.095*** (0.016)
Log within-group share ((\sigma))	0.915*** (0.018)
HTP product indicator	-1.606*** (0.373)
Firm supplies both cigarettes and HTPs	0.256*** (0.038)

Source: Authors' own calculations
Notes: Standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.10. Product characteristics include color, which signals perceived cigarette strength, especially when explicit strength labeling is not provided; format (long, slim); flavor; HTP variant; and device indicators. Full results and alternative IV specifications are reported in Table B10 in Annex B.

Table 5 presents the estimated own- and cross-price elasticity matrix. Own-price elasticities are negative and statistically significant across all product categories. Demand is most responsive among HTP users (-1.268); followed by low- and medium-price cigarette segments, which exhibit

smaller elasticities (-0.844 and -0.790, respectively); and the premium segment, with an elasticity of -0.698.

All cross-price elasticities are positive, confirming that cigarette segments and HTPs act as economic substitutes. However, substitution patterns differ markedly in magnitude. The strongest responses are observed within the cigarette market, particularly between economy- and middle-price cigarettes and between middle- and premium-price cigarettes, where cross-price elasticities reach approximately 0.35. This indicates that smokers are substantially more likely to switch across cigarette price segments than across product categories. In contrast, increases in HTP prices generate only modest increases in cigarette demand (around 0.08 percent across medium and premium segments), indicating limited switching from HTPs to cigarettes. Combined with the relatively large own-price elasticity of HTP demand, this suggests that a substantial share of the reduction in HTP consumption following a price increase is absorbed by the outside good rather than by increased cigarette consumption.

Overall, the results indicate that HTPs function as substitutes for cigarettes. However, smokers appear more likely to switch across cigarette price segments than between cigarettes and HTPs, particularly when HTP prices increase.

Table 5. Own- and cross-price elasticity matrix

Demand-segments / Price	**Low-price cigarettes**	**Medium-price cigarettes**	**Premium cigarettes**	**HTPs**
Low-price cigarettes	-0.844*** (0.255)	0.355*** (0.108)	0.193 (0.156)	0.082 (0.117)
Middle-price cigarettes	0.151*** (0.046)	-0.790*** (0.240)	0.194*** (0.056)	0.079*** (0.022)
Premium cigarettes	0.150 (0.145)	0.353** (0.187)	-0.698*** (0.201)	0.081*** (0.018)
HTPs	0.157 (0.147)	0.354*** (0.108)	0.199*** (0.057)	-1.268*** (0.348)

Source: Authors' own calculations
Notes: *** p < 0.01. Standard errors in parentheses, obtained using the delta method. Elasticities represent the percentage change in demand resulting from a one-percent increase in the corresponding product price.

To facilitate comparison with studies that distinguish only between cigarettes and HTPs, additional aggregate cross-price elasticities are calculated. The results confirm the asymmetric substitution pattern observed in the segment-level analysis. A one-percent increase in cigarette prices increases HTP demand by 0.710 (SE = 0.083, p < 0.01), whereas a one-percent increase in HTP prices increases cigarette demand by only 0.080 (SE = 0.019, p < 0.01). The stronger aggregate response of cigarettes to HTPs reflects that when all cigarette segments are treated as a single category, substitution within the cigarette market is no longer observed separately, and a larger share of adjustment is directed towards HTPs. Consistent with the segment-level results, the reverse effect remains small, indicating limited switching from HTPs to cigarettes following HTP price increases.

Robustness analyses indicate that the estimated substitution patterns are not driven by any particular definition of outside goods or by any instrumental-variables specification, indicating that the overall substitution structure remains stable. In particular, HTP own-price elasticities remain larger in absolute value than cigarette elasticities, cigarette-to-HTP cross-price elasticities remain positive, and the response of cigarette demand to higher HTP prices remains comparatively small (Table B11 in Annex B).

5. Discussion and Conclusions

This study examines price responsiveness and substitution patterns between conventional cigarettes and HTPs in Montenegro using complementary empirical approaches. Three main findings emerge. First, both cigarettes and HTPs are responsive to price changes in the long run, although the magnitude of the response differs substantially across products. The PMG estimates indicate a long-run own-price elasticity of -0.79 for cigarettes and -1.40 for HTPs. The nested-logit estimates yield comparable conclusions, with HTPs' own-price elasticity of approximately -1.27 and cigarette-segment elasticities ranging from about -0.70 to -0.84. These findings are consistent with previous evidence indicating that emerging nicotine products tend to be more price-responsive than conventional cigarettes (Cotti et al., 2022; Saffer et al., 2020; Dauchy & Shang, 2024; Jawad et al., 2018; Huang et al., 2014; Qian, 2024).

Second, the results confirm that cigarettes and HTPs are economic substitutes, although substitution is asymmetric. Segment-level elasticities indicate that substitution within the cigarette market is stronger than substitution between cigarettes and HTPs. Cross-price

elasticities between cigarette segments range from approximately 0.15 to 0.35, whereas cigarette–HTP elasticities are smaller. The strongest responses are observed between medium-price cigarettes and both neighboring cigarette segments and HTPs. At the aggregate level, a simultaneous one-percent increase in cigarette prices raises HTP demand by approximately 0.71 percent, while a one-percent increase in HTP prices increases cigarette demand by only around 0.08 percent. These results suggest that higher cigarette prices generate measurable switching towards HTPs, whereas increases in HTP prices lead only to limited switching to combustible products. Similar asymmetric substitution patterns have been reported in multi-country analyses by Dauchy and Shang (2024).

Third, the descriptive evidence and relative price analysis suggest that the evolution of the cigarette and HTP markets cannot be understood independently. Over the study period, the price gap between the two products narrowed considerably. Cointegration results further indicate a stable long-run relationship between cigarette and HTP prices, with HTP prices adjusting to developments in cigarette prices rather than the reverse. Together with the fact that a single manufacturer supplies both product categories (and holds a 96-percent share in the HTP market), the low coefficient of tax pass-through to HTP prices (0.26), and the high indirect pass-through of cigarette tax to HTP prices (0.9), these findings suggest that pricing decisions across products are interconnected. This supports the view that cigarettes and HTPs are managed within common product portfolios rather than as independent markets. By absorbing part of the tax increases, manufacturers preserved the relative price advantage of HTPs over cigarettes, thereby weakening the price signal that would otherwise induce stronger adjustments in consumer demand.

The simultaneous increase in legal sales of cigarettes and HTPs observed during part of the sample period should be interpreted with caution. Montenegro experienced a substantial decline in illicit cigarette trade following strengthened enforcement measures and regulatory reforms (Economics for Health (formerly Tobacconomics), 2023; Čizmović et al., 2024), implying that part of the increase in legal cigarette sales reflects market formalization rather than higher consumption. At the same time, HTPs represented a newly introduced product category undergoing rapid diffusion. Given the substantial increases in tobacco taxes and prices during the study period, overall tobacco consumption (legal and illegal) would be expected to decline over time. Therefore, the observed growth in legal sales is likely to reflect the combined effects of market formalization, increased affordability, and the expansion of a new product category, rather than an increase in total tobacco use. Consequently, common demand-side factors and market formalization appear to have played a more important role in aggregate market trends than substitution effects alone.

Several limitations should be acknowledged. First, the analysis relies on assumptions about the size of the outside good, which primarily refers to illicit cigarettes and other tobacco products. Although alternative specifications produced very similar results, measurement error in the outside-good share may affect the magnitude of estimated elasticities. If illicit consumption declined more rapidly than assumed, own-price elasticities may be slightly overstated, whereas slower reductions in illicit trade would bias them downward. However, robustness analyses indicate that these effects are quantitatively limited.

Second, the observation period for HTPs remains relatively short because these products entered the Montenegrin market only in late 2019.

Consequently, the estimated HTP elasticities reflect an early stage of market development and may evolve as the market matures and consumer preferences change. Third, the brand-level data do not allow for the identification of heterogeneous responses across user groups. Previous survey evidence indicates that dual users may exhibit different behavioral responses from exclusive users (Hwang et al., 2019b; Lee et al., 2024). Therefore, the reported elasticities should be interpreted as average market responses rather than individual-level behavioral parameters.

Fourth, aggregate time-series models did not identify statistically significant cross-price effects between cigarettes and HTPs. This does not contradict the nested-logit findings. Because cigarette and HTP prices are highly correlated and exposed to common tax shocks, aggregate models have limited ability to isolate substitution effects. In contrast, the nested-logit framework exploits within-period variation across products and market segments, making it more suitable for identifying substitution patterns.

Fifth, although the observed price dynamics and the presence of firms operating in both product categories suggest potential supply-side interactions, a full structural supply model could not be estimated because the available data do not contain information on product-level marginal costs, wholesale prices, and other inputs required to recover firms' pricing behavior explicitly, which are necessary for the full BLP model. Consequently, potential supply-side interactions are captured only indirectly within the demand framework. Finally, Montenegro currently classifies HTPs as smokeless tobacco products, exempting them from some smoke-free regulations applicable to cigarettes. This regulatory asymmetry creates a non-price competitive advantage that cannot be fully separated from price-induced substitution in the available data.

Despite these limitations, this study has made an important contribution to the still-limited literature on HTP demand by providing evidence from a middle-income country using high quality data and by combining dynamic demand models with a differentiated-products framework that explicitly incorporates market segmentation, outside goods, and interactions between products supplied by the same manufacturers. To our knowledge, relatively few previous studies have simultaneously considered these dimensions within a single empirical framework. Although the analysis focuses on Montenegro, the findings may have broader relevance for countries experiencing the rapid emergence of HTPs under differentiated tax regimes. The combination of strong HTP price responsiveness, asymmetric substitution, and the coexistence of cigarettes and HTPs may be particularly relevant for middle-income and European countries undergoing similar market transitions. Nevertheless, differences in market maturity, regulatory environments, and consumer preferences imply that the magnitudes of elasticities cannot be mechanically transferred across countries.

Overall, the results indicate that HTPs act as substitutes for cigarettes, although the magnitude of substitution remains limited. Consequently, changes in market shares of individual products should not automatically be interpreted as proportional changes in overall tobacco consumption. In increasingly diversified tobacco markets, tobacco taxation can no longer be designed on a product-by-product basis. Effective fiscal policy requires a market-wide perspective that recognizes the interdependence of cigarettes and alternative nicotine products and places relative prices at the center of the tobacco control strategy.

Policy Recommendations

The findings of this study have several implications for tobacco control policy in Montenegro and in countries experiencing similar transitions in tobacco product markets:

- **The Government should design tobacco taxation from the perspective of the entire tobacco market rather than treating cigarettes and HTPs as independent product categories.** The estimated cross-price elasticities indicate that consumers substitute between products, implying that tax changes affecting one category also influence demand for the other (World Health Organization, 2021b). Tax policies that favor certain products give the tobacco companies excellent opportunities to employ pricing strategies that enhance substitution opportunities, thereby potentially increasing overall consumption.
- **The Government should continue increasing HTP excise taxes as part of its tobacco control strategy, with annual increases that account for both inflation and real income growth and, ideally, exceed their combined growth in order to reduce HTP affordability.** The relatively high own-price elasticity of HTP demand suggests that such tax increases can effectively reduce HTP consumption. Furthermore, the findings suggests that such HTP price increases would generate only limited switching to cigarettes.
- **The Government should introduce a more ambitious multi-year excise schedule for HTPs, similar to the existing framework for cigarettes, and continue gradually narrowing the remaining tax differential between the two product categories with a goal of convergence.** A coordinated approach to future tax increases would improve policy credibility, limit manufacturers' pricing discretion, and help ensure that relative prices evolve consistently with public

health objectives, in line with WHO recommendations (World Health Organization, 2021a, 2021b).

- **The Government should amend the smoke-free legislation to explicitly include HTPs.** The current exemption of HTPs from indoor-use bans applicable to cigarettes creates a non-price competitive advantage that may reinforce price-driven substitution. Extending indoor-use restrictions currently applied to cigarettes would ensure more consistent regulation across tobacco products and align Montenegro's regulatory framework with WHO recommendations (Perucic et al., 2022; WHO, 2003; World Health Organization, 2021b).
- **The Government should strengthen tobacco market surveillance and data collection systems.** Expanding administrative monitoring to all tobacco products and complementing these data with periodic consumer surveys would improve understanding of dual use, switching behavior, and heterogeneous responses across population groups. Such information will become increasingly important as nicotine markets continue to diversify.

Overall, the findings suggest that the objective of tobacco control and tobacco product tax policies should not be to encourage switching between products but rather to reduce overall tobacco consumption while preventing the emergence of new forms of nicotine dependence.

References

Allcott, H., & Rafkin, C. (2021). *Optimal Regulation of E-Cigarettes: Theory and Evidence* (Working Paper No. 27000). National Bureau of Economic Research. http://www.nber.org/papers/w27000

Berry, S., Levinsohn, J., & Pakes, A. (1995). Automobile Prices in Market Equilibrium. *Econometrica*, *63*(4), 841–890. https://doi.org/10.2307/2171802

Berry, S. T. (1994). Estimating Discrete-Choice Models of Product Differentiation. *The RAND Journal of Economics*, *25*(2), 242–262. https://doi.org/10.2307/2555829

Campaign for Tobacco-Free Kids. (2023). *Heated Tobacco Products: Global Regulation and Recommended Measures*. Campaign for Tobacco-Free Kids. https://assets.tobaccofreekids.org/emerging-products/resources/HTPs-Global-Regulation-2023.pdf

Cheng, K., Chaloupka, F. J., Shang, C., Ngo, A., Fong, G. T., Borland, R., Heckman, B. W., Levy, D. T., & Cummings, K. M. (2019). Prices, use restrictions and electronic cigarette use—Evidence from wave 1 (2016) US data of the ITC Four Country Smoking and Vaping Survey. *Addiction*, *114*(S1), 115–122. https://doi.org/10.1111/add.14562

Čizmović, M., Ivanović, I., & Vlahović, A. (2024). *Heated tobacco products use in Montenegro* (Working Paper Series 24/12/1). ISEA. www.economicsforhealth.org/research/heated-tobacco-products-usein-montenegro-working-paper-series/

Čizmović, M., Mugoša, A., Vukčević, M., & Vulović, V. (2026). Pricing strategies of the tobacco companies in response to cigarette excise tax increases in Montenegro. *PLOS ONE*, *21*(6), e0335670. https://doi.org/10.1371/journal.pone.0335670

Čizmović, M., Vlahović, A., Ivanović, I., & Kovačević, M. (2024). *Cigarette Affordability in Montenegro* (Working Paper Series 24/12/2). ISEA. https://www.economicsforhealth.org/research/cigarette-affordability-in-montenegroworking-paper-series/

Cotti, C., Courtemanche, C., Maclean, J. C., Nesson, E., Pesko, M. F., & Tefft, N. W. (2022). The Effects of E-Cigarette Taxes on E-Cigarette Prices and Tobacco Product Sales: Evidence from Retail Panel Data. *Journal of Health Economics*, *86*, 102676. https://doi.org/10.1016/j.jhealeco.2022.102676

Dauchy, E., & Shang, C. (2024). The price elasticity of heated tobacco and cigarette demand: Empirical evaluation across countries. *Health Economics*, *33*(12), 2708–2722. https://doi.org/10.1002/hec.4888

Do, V. V., Shang, C., Huang, J., Islam, T., Pechacek, T. F., & Weaver, S. R. (2025). Volumetric choice experiment to estimate the impact of e-cigarette and heated tobacco product characteristics on substitution and complementary use among adults who smoke cigarettes and recently initiated e-cigarette use. *BMJ Open*, *15*(7), e100073. https://doi.org/10.1136/bmjopen-2025-100073

Economics for Health (formerly Tobacconomics). (2023). *The Illicit Cigarette Market in Montenegro*. Economics for Health. https://www.economicsforhealth.org/files/research/846/montenegro-illicit-trade-report-v3.0.pdf

ESPAD. (2024). *ESPAD 2024 Student Questionnaire Database (Heated Tobacco Questions)* [Data set]. https://data.espad.org/search-questions/

Euromonitor International. (2025). *Passport Global Market Information Database* [Data set]. https://www.euromonitor.com/

Farhi, E., & Gabaix, X. (2020). Optimal Taxation with Behavioral Agents. *American Economic Review*, *110*(1), 298–336. https://doi.org/10.1257/aer.20151079

Gandhi, A., & Houde, J.-F. (2019). Measuring Substitution Patterns in Differentiated-Products Industries. *NBER Working Papers, NBER Working Papers*, Article 26375. https://ideas.repec.org//p/nbr/nberwo/26375.html

Gruber, J., & Kőszegi, B. (2004). Tax incidence when individuals are time-inconsistent: The case of cigarette excise taxes. *Journal of Public Economics*, *88*(9–10), 1959–1987. https://doi.org/10.1016/j.jpubeco.2003.06.001

Huang, J., Tauras, J., & Chaloupka, F. J. (2014). The impact of price and tobacco control policies on the demand for electronic nicotine delivery systems. *Tobacco Control*, *23*(suppl 3), iii41–iii47. https://doi.org/10.1136/tobaccocontrol-2013-051515

Hwang, J. H., Ryu, D. H., & Park, S.-W. (2019a). Heated tobacco products: Cigarette complements, not substitutes. *Drug and Alcohol Dependence*, *204*, 107576. https://doi.org/10.1016/j.drugalcdep.2019.107576

Hwang, J. H., Ryu, D. H., & Park, S.-W. (2019b). Heated tobacco products: Cigarette complements, not substitutes. *Drug and Alcohol Dependence*, *204*, 107576. https://doi.org/10.1016/j.drugalcdep.2019.107576

Hylleberg, S., Engle, R. F., Granger, C. W. J., & Yoo, B. S. (1990). Seasonal integration and cointegration. *Journal of Econometrics*, *44*(1), 215–238. https://doi.org/10.1016/0304-4076(90)90080-D

Jawad, M., Lee, J. T., Glantz, S., & Millett, C. (2018). Price elasticity of demand of non-cigarette tobacco products: A systematic review and meta-analysis. *Tobacco Control*, *27*(6), 689–695. https://doi.org/10.1136/tobaccocontrol-2017-054056

Johansen, S. (1988). Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control*, *12*(2), 231–254. https://doi.org/10.1016/0165-1889(88)90041-3

Joossens, L., Merriman, D., Ross, H., & Raw, M. (2010). The impact of eliminating the global illicit cigarette trade on health and revenue. *Addiction*, *105*(9), 1640–1649. https://doi.org/10.1111/j.1360-0443.2010.03018.x

Lee, S., Xu, S. S., Yan, M., Gravely, S., Quah, A. C. K., Seo, H. G., Lim, S., Cho, S., Kim, Y., & Fong, G. T. (2024). Patterns of cigarette, heated tobacco product, and nicotinevaping product use among Korean adults: Findings from the2020 ITC Korea Survey. *Tobacco Induced Diseases*, *22*(April), 1–11. https://doi.org/10.18332/tid/186273

López Nicolás, Á. (2023). *Tobacco Taxes in the European Union: An Evaluation of the Effects of the European Commission's Proposals for a New Tobacco Tax Directive on the Markets for Cigarettes and Fine Cut Tobacco*. http://hdl.handle.net/10317/13803

Maddala, G. S., & Wu, S. (1999). A Comparative Study of Unit Root Tests with Panel Data and a New Simple Test. *Oxford Bulletin of Economics and Statistics*, *61*(S1), 631–652. https://doi.org/10.1111/1468-0084.0610s1631

Marzioni, S., Pandimiglio, A., & Spallone, M. (2023). An econometric analysis of the demand for cigarettes in Italy after the introduction of heated tobacco products in 2016. *British Food Journal*, *125*(13), 425–435. https://doi.org/10.1108/BFJ-09-2022-0760

Mugosa, A., Lakovic, T., Kovačević, Milica, Cizmovic, M., & Popovic, M. (2020). *Adult Tobacco Use in Montenegro [Report]. ISEA*. https://www.economicsforhealth.org

Nevo, A. (2000). A Practitioner's Guide to Estimation of Random-Coefficients Logit Models of Demand. *Journal of Economics & Management Strategy*, *9*(4), 513–548. https://doi.org/10.1111/j.1430-9134.2000.00513.x

O'Donoghue, T., & Rabin, M. (2006). Optimal sin taxes. *Journal of Public Economics*, *90*(10), 1825–1849. https://doi.org/10.1016/j.jpubeco.2006.03.001

Olesiński, B. (2020). The Analysis of the Tobacco Product Bans Using a Random Coefficients Logit Model. *Central European Journal of Economic Modelling and Econometrics*, *12*(2), 113–144. https://doi.org/10.24425/cejeme.2020.133718

Perucic, A.-M., Sandoval, R. C., Malik, S., & Morales-Zamora, G. (2022). Taxation of novel and emerging nicotine and tobacco products (HTPs, ENDS, and ENNDS) globally and in Latin America. *Revista Panamericana De Salud Publica = Pan American Journal of Public Health*, *46*, e175. https://doi.org/10.26633/RPSP.2022.175

Pesaran, M. H. (2004). 'General Diagnostic Tests for Cross Section Dependence in Panels.' *Cambridge Working Papers in Economics, Cambridge Working Papers in Economics*, Article 0435. https://ideas.repec.org//p/cam/camdae/0435.html

Pesaran, M. H. (2007). A simple panel unit root test in the presence of cross-section dependence. *Journal of Applied Econometrics*, *22*(2), 265–312. https://doi.org/10.1002/jae.951

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds Testing Approaches to the Analysis of Level Relationships. *Journal of Applied Econometrics*, *16*(3), 289–326.

Pesaran, M. H., Shin, Y., & Smith, R. P. (1999). Pooled Mean Group Estimation of Dynamic Heterogeneous Panels. *Journal of the American Statistical Association*, *94*(446), 621–634. https://doi.org/10.2307/2670182

Qian, T. (2024). *Own-Price Elasticity of Demand for Heated Tobacco Products* (SSRN Scholarly Paper No. 4861681). Social Science Research Network. https://doi.org/10.2139/ssrn.4861681

Saffer, H., Dench, D., Grossman, M., & Dave, D. (2020). E-Cigarettes and Adult Smoking: Evidence from Minnesota. *Journal of Risk and Uncertainty*, *60*(3), 207–228. https://doi.org/10.1007/s11166-020-09326-5

Stoklosa, M., Drope, J., & Chaloupka, F. J. (2016). Prices and E-Cigarette Demand: Evidence From the European Union. *Nicotine & Tobacco Research: Official Journal of the Society for Research on Nicotine and Tobacco*, *18*(10), 1973–1980. https://doi.org/10.1093/ntr/ntw109

Tauras, J. A., Peck, R. M., & Chaloupka, F. J. (2006). The Role of Retail Prices and Promotions in Determining Cigarette Brand Market Shares. *Review of Industrial Organization*, *28*(3), 253–284. https://doi.org/10.1007/s11151-006-0016-6

Vincent, D. W. (2015). The Berry–Levinsohn–Pakes Estimator of the Random-coefficients Logit Demand Model. *The Stata Journal*, *15*(3), 854–880. https://doi.org/10.1177/1536867X1501500317

WHO. (2003). *WHO Framework Convention on Tobacco Control*. https://fctc.who.int/publications/m/item/who-framework-convention-on-tobacco-control

World Health Organization. (2021a). *WHO Report on the Global Tobacco Epidemic 2021: Addressing New and Emerging Products*. World Health Organization. https://www.who.int/publications/i/item/9789240032095

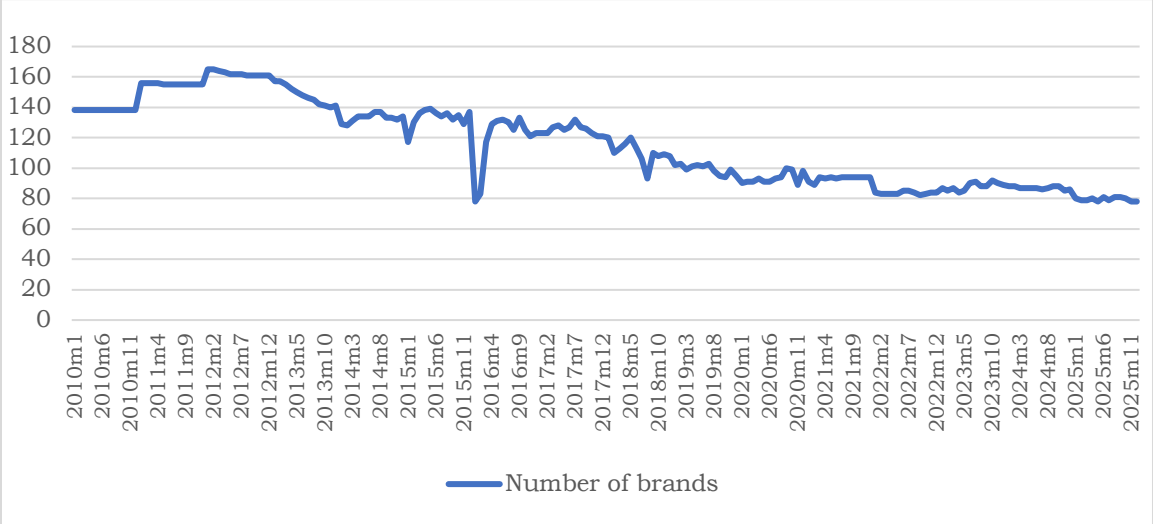
World Health Organization. (2021b). *WHO Technical Manual on Tobacco Tax Policy and Administration*. World Health Organization. https://www.who.int/publications/i/item/9789240019188

Zivot, E., & Andrews, D. W. K. (1992). Further Evidence on the Great Crash, the Oil-Price Shock, and the Unit-Root Hypothesis. *Journal of Business & Economic Statistics*, *10*(3), 251–270. https://doi.org/10.2307/1391541

Annexes

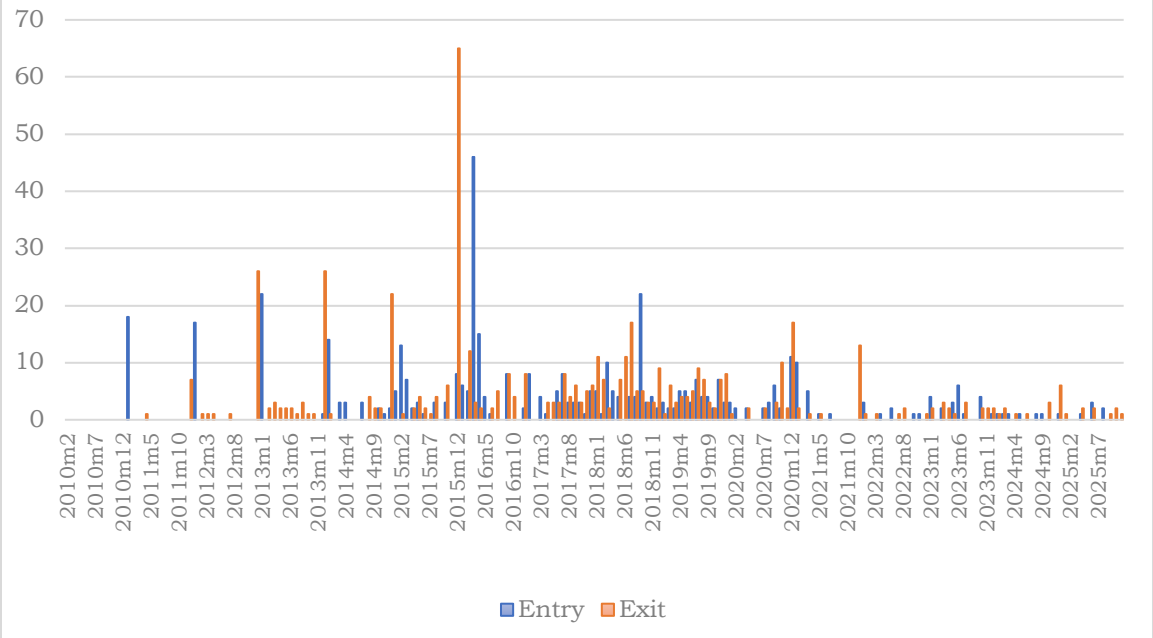
Annex A. Additional Figures and Tables

Figure A1. Number of cigarette brands (2010–2025)



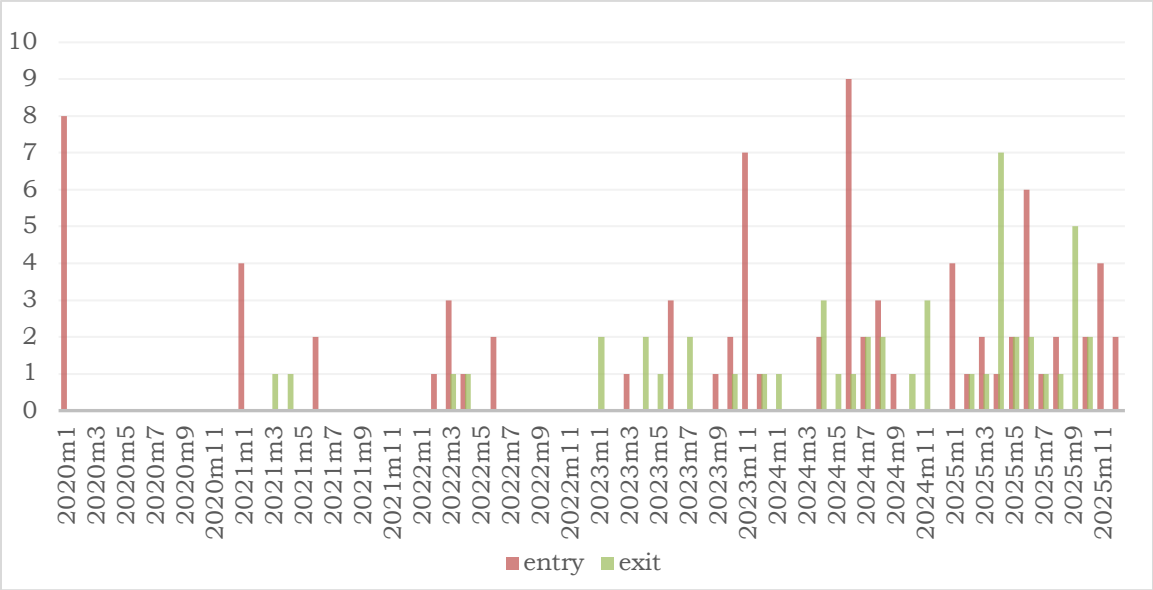
Source: Ministry of Finance Directorate for Issuing Permits for the Production, Processing, and Trade of Tobacco Products

Figure A2. Monthly number of cigarette brand entries and exits (2010–2025)



Source: Ministry of Finance Directorate for Issuing Permits for the Production, Processing, and Trade of Tobacco Products

Figure A3. Monthly number of HTP brand entries and exits (2020–2025)



Source: Ministry of Finance Directorate for Issuing Permits for the Production, Processing, and Trade of Tobacco Products

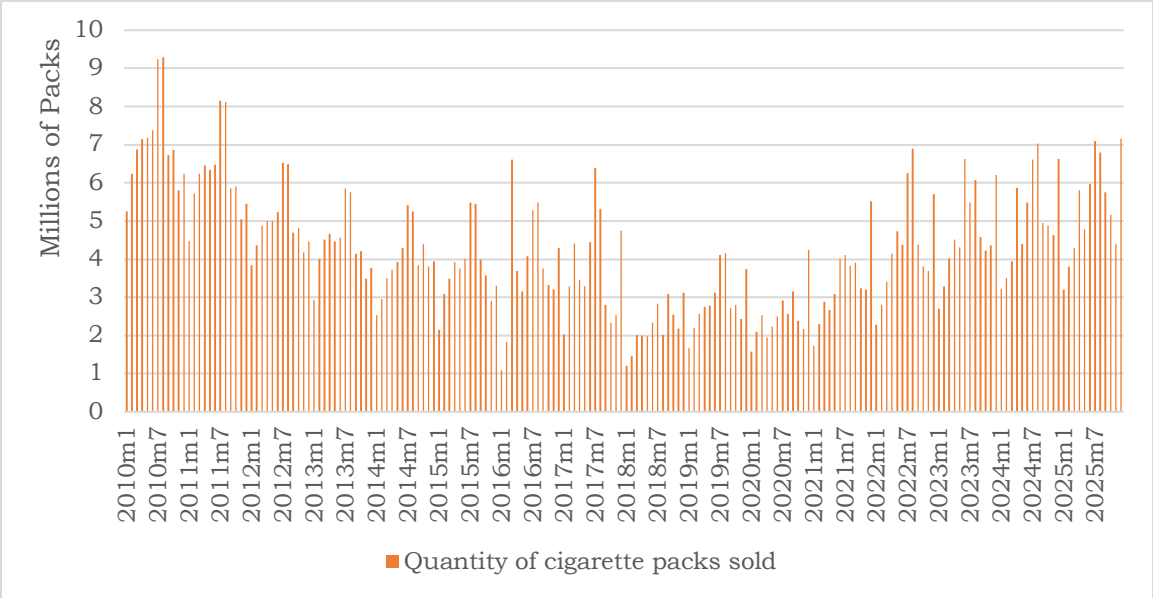
Table A1. Most-sold, premium, and cheapest brands' prices in euros (2020–2025)

Year	Most-sold brand	Nom. price	Real price	Premium brand	Nom. price	Real price	Cheapest brand	Nom. price	Real price
2020	Winston Xstyle long blue	2.4	2.40	Marlboro red	3.3	3.30	LD Club compact blue	2.0	2.00
2021		2.5	2.44		3.4	3.32	Una slims gold	2.0	1.95
2022		2.7	2.33		3.5	3.02		2.3	1.99
2023		2.9	2.31		3.7	2.94		2.5	1.99
2024		3.1	2.39		3.9	3.00		2.6	2.00
2025		3.2	2.37		4.0	2.96		2.7	2.00

Source: Ministry of Finance Directorate for Issuing Permits for the Production, Processing, and Trade of Tobacco Products

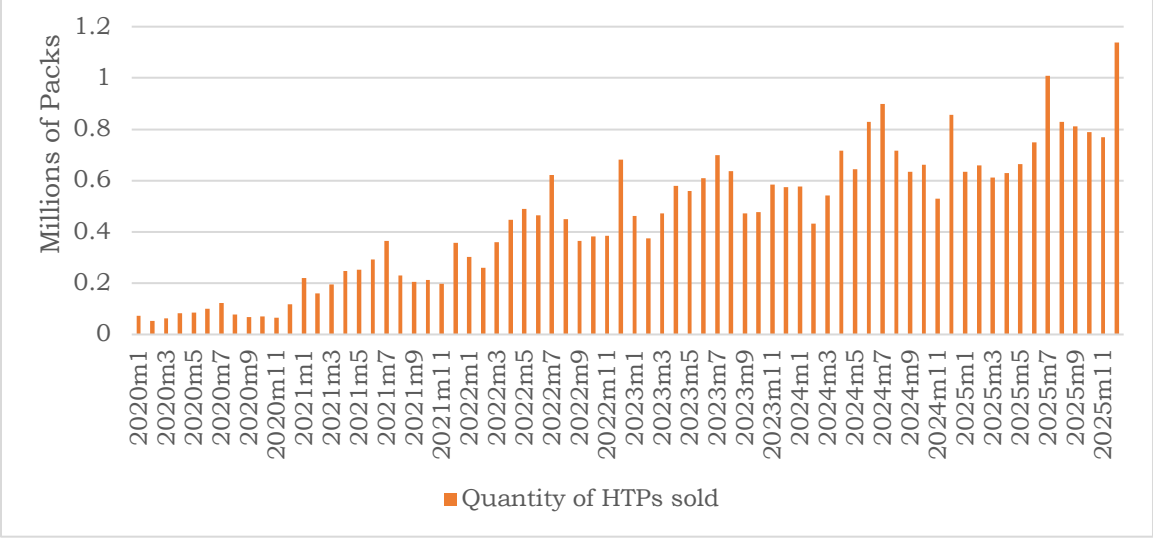
Note: Real values are obtained by deflating nominal price using the consumer price index (2010 = 100).

Figure A4. Monthly sales of cigarette packs in Montenegro (2010–2025)



Source: Ministry of Finance Directorate for Issuing Permits for the Production, Processing, and Trade of Tobacco Products

Figure A5. Monthly sales of HTP packs in Montenegro (2020–2025)



Source: Ministry of Finance Directorate for Issuing Permits for the Production, Processing, and Trade of Tobacco Products

Table A2. Average nominal and real net wage and CPI

Year	Average nominal net wage (€)	Average real net wage (€)	CPI (2010=100)
2020	524	450	116.44
2021	532	446	119.25
2022	712	528	134.80
2023	792	541	146.37
2024	876	579	151.26
2025	1012	644	157.15

Source: Monstat, Labour Force Survey

Note: Real average net wage values are calculated by the authors using the corresponding CPI (2010=100) obtained from Monstat.

Table A3. Excise tax calendar from 2010 to 2025

Year	Specific excise tax (in € per 1,000 sticks)	Ad valorem excise tax (% cigarette retail price)	HTP excise tax (€/kg of tobacco mixture)
2020	33.5	30.5	26.21
2021	37	29	29.30
2022	40.5	27.5	30.50
2022	44	26	100.00
2023	47.5	24.5	145.00
2023	49	24.5	145.00
2024	50.5	24.5	190.00
2024	52	24.5	190.00
2025	53.5	24.5	190.00
2026	58.85	24.5	190.00
2026	64.74	24.5	190.00
2027	71.21	24.5	N/A
2027	78.33	24.5	N/A
2028	86.16	24.5	N/A
2028	94.78	24.5	N/A

Source: Law on Excise Taxes

Annex B. Technical Details of Methodology

This annex provides the full technical specifications for the four empirical stages described in Section 3 of the main text. It documents the estimating equations, variable construction, instrument sets, identification assumptions, and robustness procedures underlying the reported results.

B1. Price Dynamics and Long-Run Cointegration

Unit-root tests are applied to the log real weighted-average retail prices for cigarettes and HTPs and to their ratio, using the Zivot and Andrews (1992) procedure. This test permits an endogenous single structural break in the intercept, trend, or both, under the null of a unit root against the alternative of trend-stationarity with a break. It is preferred over conventional augmented Dickey–Fuller (ADF) tests because Montenegro's tobacco market underwent a pronounced shift during 2020–2022. Under such conditions, ADF tests may spuriously fail to reject or reject the null. Given the monthly frequency of the series, stationarity is also evaluated using the Hylleberg–Engle–Granger–Yoo (HEGY) seasonal unit-root test, which allows for the identification of both non-seasonal and seasonal unit roots (Hylleberg et al., 1990).

Given evidence of unit root behavior in the price series, the long-run relationship between log cigarette prices and log HTP prices is assessed using two complementary procedures. The Johansen (1988) maximum-likelihood procedure tests the rank of the cointegrating space using the trace statistic; lag order is selected by the Akaike information criterion, with residuals checked for normality and absence of autocorrelation. The Pesaran, Shin, and Smith (2001) ARDL bounds test is additionally applied because it remains valid when variables are of mixed integration order.

Where cointegration is confirmed, the long-run coefficient and error-correction speed are estimated within an ARDL framework augmented with a post-break interaction term, given the structural break identified in June 2022. The estimated long-run coefficient captures the equilibrium proportionality between the two price series. The error-correction coefficient measures the speed of mean reversion following a deviation from this equilibrium.

B2. Own-Price Demand Responses: Full specifications

B2.1 PMG estimating equation

The empirical specification for the PMG panel error-correction model is:

$$\Delta \ln Q_{it} = \varphi_i [\ln Q_{i,t-1} - \beta \ln P_{i,t-1} - \gamma X_{i,t-1}] + \sum_k \lambda_{ik} \Delta \ln Q_{i,t-k} + \sum_k \delta_{ik} \Delta \ln P_{i,t-k} + \sum_k \theta_{ik} \Delta X_{i,t-k} + \varepsilon_{it} \quad \text{(B1)}$$

where Q_{it} denotes monthly sales of product i in period t, P_{it} is the corresponding real retail price, and X_{it} includes real net wages, monthly seasonal dummies, and a deterministic time trend. The long-run coefficient β is the price elasticity of demand after full equilibrium adjustment. The error-correction coefficient φ_i measures the speed of return to long-run equilibrium; a negative and statistically significant value confirms a stable long-run relationship. The cross-product average half-life of a shock is computed as:

$$HL = \frac{ln(0.5)}{ln(1 + \bar{\varphi})}$$

where $\bar{\varphi}$ is the cross-product average adjustment speed. Prior to estimation, cross-sectional dependence is examined using the Pesaran (2004) CD test, and panel unit-root tests are applied: the CIPS test

(Pesaran, 2007) as the primary statistic and the Maddala and Wu (1999) test as a robustness check.

B2.2 Aggregate ARDL specification and IV specification

The aggregate ARDL robustness check is specified as:

$$\Delta \ln Q_t = \alpha + \lambda[\ln Q_{t-1} - \beta \ln P_{t-1} - \gamma X_{t-1}] + \sum_j \delta_j \Delta \ln Q_{t-j} + \sum_j \theta_j \Delta \ln P_{t-j} + \sum_j \psi_j \Delta X_{t-j} + u_t \quad \text{(B2)}$$

where Q_t and P_t are the aggregate quantity sold and the real sales-weighted average price, and X_t includes real net wages, seasonal dummies, and policy controls. Lag order is selected by the Akaike information criterion. The Pesaran–Shin–Smith bounds test evaluates the existence of a long-run relationship. Residual diagnostics include the Breusch–Godfrey LM test for serial correlation, the Breusch–Pagan test for heteroskedasticity, and CUSUM and CUSUMSQ stability tests.

IV regressions address potential endogeneity of retail prices. Excise taxes serve as instruments because they shift retail prices by changing statutory tax liability and affect demand primarily through their effect on consumer prices. For cigarettes, the instruments are the real specific excise tax and the real minimum excise tax per pack. For HTPs, the instrument is the excise tax expressed per pack. Instrument relevance is evaluated using first-stage F-statistics and the Kleibergen–Paap rk Wald F-statistic.

B3. Nested-Logit Demand Model: Technical specification

B3.1 Why time-series cross-price estimation is infeasible

The two aggregate price series for cigarettes and HTPs are highly correlated ($r \approx 0.85$), driven by common excise shocks, inflation, and market-wide

pricing behavior by manufacturers who supply both categories. Including both prices in the same dynamic panel equation creates multicollinearity, rendering cross-price coefficients numerically unstable. Systematic empirical testing of ARDL cross-price specifications confirms this: estimated cross-price coefficients range from −1.23 to +0.11 with no consistent sign or statistical significance across otherwise equivalent specifications. The nested-logit model identifies cross-price responses from within-period cross-sectional variation in prices and shares, which is not subject to this collinearity problem.

B3.2 Consumer choice and mean utility

In each month *t*, consumer *i* selects the product that maximizes utility:

$$u_{ijt}=\delta_{jt}+\varepsilon_{ijt} \quad \text{(B3)}$$

where δ_{jt} is the mean utility of product *j* shared by all consumers and ε_{ijt} is an i.i.d. idiosyncratic preference shock. Mean utility is modelled as:

$$\delta_{jt}=\alpha p_{jt}+\gamma(p_{jt}\times Portfolio_j)+X_j'\beta+\delta^g+\delta_t+\xi_{jt} \quad \text{(B4)}$$

where p_{jt} is the real retail price; $Portfolio_j$ is a binary indicator equal to 1 for all brands belonging to the sole vertically integrated manufacturer that simultaneously markets both cigarette and HTP brands in Montenegro; X_j is a vector of observable product characteristics (color, which signals perceived cigarette strength, especially when explicit strength labeling is not provided; format, such as long or slim; flavor; HTP variant; and device indicators); δ^g and δ_t are product-segment and market-month fixed effects; and ξ_{jt} captures unobserved product characteristics. The parameter α is the mean price sensitivity for non-portfolio products; α + γ is the effective

price sensitivity for portfolio products. This distinction is made only on the demand side, as the model does not estimate firm conduct, marginal costs, or markups.

B3.3 Nested-logit structure and estimating equation

Products are assigned to four nests: low-price cigarettes, medium-price cigarettes, premium cigarettes, and HTPs. The within-nest share of product j in nest g in month t is:

$$s_{j|g,t} = \frac{s_{jt}}{\sum_{k \in g} s_{kt}}$$

The nesting parameter σ ∈ (0, 1) governs within-nest substitutability. Berry (1994) shows that the nested-logit system can be linearized to yield the following estimating equation:

$$\ln(s_{jt}) - \ln(s_{0t}) = \alpha p_{jt} + \gamma (p_{jt} \times Portfolio_j) + \sigma \ln(s_{j|g,t}) + X_j' \beta + \delta^g + \delta_t + \varepsilon_{jt} \quad \text{(B5)}$$

The dependent variable is the log ratio of product j's market share to the outside-good share. The unit of observation is the product-month pair; with approximately 123 products observed over 71 months, the dataset contains 6,975 observations. The model is estimated using 2SLS with market-clustered standard errors.

B3.4 Outside-good construction

Total market size in month t is constructed as:

$$M_t = \frac{Q_t^C}{1 - illicit_t} + Q_t^H + other_t \times Q_t^C \quad \text{(B6)}$$

where Q^tC is observed legal cigarette sales, Q^tH is observed HTP sales, *illicit* is the estimated share of illicit cigarettes in total cigarette consumption, and *other* is the ratio of other tobacco product consumption to legal cigarette sales (roll-your-own and e-cigarettes). In the baseline specification, $illicit_t$ follows a trajectory: constant at 51 percent (January 2020–July 2021); declining linearly to 24 percent (July 2021–February 2022); then declining to 15 percent (December 2024) and 10 percent (December 2025).

Three robustness scenarios are estimated alongside the baseline. First: constant at 51 percent (January 2020–July 2021), declining linearly to 24 percent (July 2021–February 2022), and constant at 24 percent thereafter. Second: a moderate post-2022 decline (illicit shares of 22/20/18/15 percent for 2023–2025). The outside good is constructed using benchmark information from the nationally representative STC-MNE surveys conducted in 2020 and 2022, which provide estimates of illicit cigarette consumption and the prevalence of other tobacco product use.

A third robustness exercise uses the constant-denominator construction (Olesiński, 2020) The monthly adjusted market size is first computed using equation (B6), and the denominator for all share calculations is then set to the maximum value observed over the entire sample. Unlike the time-varying baseline, this fixed denominator means that the outside good absorbs not only illicit trade and other tobacco products but also temporal variation in legal-market participation. This specification is used only as a robustness check because fixing the denominator at the historical maximum may overstate the outside option in earlier periods of structural change.

B3.5 Elasticity computation

Elasticities are computed via counterfactual simulation. The mean utility of each product, net of the within-nest component, is first recovered as:

$$\delta *_{jt} = [\ln(s_{jt}) - \ln(s_{0t})] - \sigma \ln(s_{j|g,t}) \quad \text{(B7)}$$

A simultaneous one-percent increase in the real prices of all products in segment *j* is then applied. Counterfactual mean utility for product *k* is:

$$\delta^{f}_{kt} = \delta *_{kt} + \alpha^{eff}_{k} \cdot 0.01 \cdot p_{kt} \cdot I_{kj} \quad \text{(B8)}$$

where $\alpha^{k}eff = \alpha + \gamma \cdot$

$Portfolio_k$ is the effective price coefficient and $I_{kj} = 1$ if product *k* belongs to segment *j*. New market shares are simulated using the nested-logit share equations and aggregated to segment-level quantities. The segment-level elasticity is:

$$\varepsilon_{ij} = \frac{(Q_i^f - Q_i^0)/Q_i^0}{0.01} \quad \text{(B9)}$$

yielding a 4×4 elasticity matrix. Aggregate cigarette-HTP elasticities are obtained by simultaneously increasing prices across all three cigarette segments. Standard errors are computed using the delta method applied to the covariance matrix V(α, γ, σ).

A full random-coefficients BLP model was estimated as an additional robustness check but is not used as the main specification. Because most product characteristics are time-invariant, standard BLP instruments lose identifying variation once brand-fixed effects are absorbed; additionally,

within-brand price variation is driven primarily by common excise increases that coincided with the rapid formalization of the illicit market, making it difficult to separate genuine price responses from shifts in legal-market participation. The nested-logit specification avoids these problems by relying on cross-sectional variation within periods.

Table B1. HEGY seasonal unit-root tests

Series	**t[0]**	**t[π]**	**F (all seasonal frequencies)**	**Conclusion**
Cigarette prices	-2.199	-2.100	3.902	Non-stationary in levels
HTP prices	-1.597	-1.447	2.529	Non-stationary in levels
Relative price ratio	-1.373	-1.568	2.800	Non-stationary in levels

Source: Authors' own calculations
Notes: HEGY tests fail to reject the presence of a non-seasonal unit root in all three series. Full test statistics are available upon request. All variables are stationary in first differences.

Table B2. Zivot–Andrews structural break test

Variable	**Test statistic**	**Break date**	**5% critical value**
Relative price ratio	-6.037	June 2022	-5.08

Source: Authors' own calculations

Table B3. Johansen Cointegration test and VECM results

Parameter	**Coefficient**	**Standard error**
Johansen trace statistic (r = 0)	19.734	n/a
5% critical value	18.170	n/a
Johansen max-eigen statistic (r = 0)	18.861	n/a
5% critical value	16.870	n/a
Cointegrating equation		
Log cigarette price	1.569***	(0.145)
Adjustment coefficients		
Δ Log HTP price	-0.298***	(0.090)
Δ Log cigarette price	0.040	(0.088)

Source: Authors' own calculations

Notes: Johansen trace and maximum eigenvalue tests indicate one cointegrating relationship between cigarette and HTP prices. The cointegrating vector is normalized on HTP prices. Adjustment coefficients indicate that deviations from the long-run equilibrium are corrected primarily through changes in HTP prices, while cigarette prices appear weakly exogenous. Standard errors are reported in parentheses. *** p < 0.01.

Table B4. ARDL bounds test

Statistic	**Value**
F-statistic	6.037
t-statistic	-3.312
Decision (5%)	Cointegration confirmed

Source: Authors' own calculations

Table B5. Panel unit-root tests

Variable	MW x^2	p-value	CIPS Zt-bar	p-value	Classification
Real cigarette price	125.188	1.000	1.713	0.957	I(1)
Cigarette sales volume	805.714	0.000	-5.704	0.000	I(0)
Real net wages	376.855	0.000	46.735	1.000	Mixed / borderline I(1)
Real HTP price	28.798	0.987	-1.675	0.047	Predominantly I(1)
HTP sales volume	71.080	0.017	2.155	0.984	Mixed

Source: Authors' own calculations
Notes: Results correspond to the specification with a deterministic trend and three lags. MW denotes the Maddala–Wu (1999) panel unit-root test and CIPS denotes the Pesaran (2007) cross-sectionally augmented IPS test. The tests indicate a mixture of I(0) and I(1) variables, while no evidence of integration of order two is found, supporting the use of the PMG estimator. All variables are stationary in first differences.

Table B6. Unit-root tests with endogenous structural breaks (Zivot–Andrews) aggregate data

Variable	Test statistic	Break date	5% critical value	Integration order
Real cigarette price	-4.367	2022m2	-5.08	I(1)
Real HTP price	-4.554	2022m3	-5.08	I(1)
Cigarette sales volume	-7.503	2022m10	-5.08	I(0)
HTP sales volume	-5.942	2020m12	-5.08	I(0)
Real net wages	-4.897	2022m1	-5.08	I(0) with structural break

Source: Authors' own calculations
Notes: Results are based on Zivot–Andrews tests allowing for endogenous structural breaks in both the intercept and trend. Rejection of the null hypothesis indicates stationarity around a structural break. The results indicate a mixture of I(0) and I(1) variables, supporting the use of ARDL models. All variables are stationary in first differences.

Table B7. Aggregate ARDL and IV estimates

Variable	ARDL cigarettes	IV cigarettes	ARDL HTPs	IV HTPs
Long-run effects				
Real price	-1.037* (0.527)	-1.051** (0.453)	-1.650** (0.676)	-1.405** (0.563)
Real net wages	0.970*** (0.163)	0.972*** (0.131)	2.084*** (0.295)	1.901*** (0.215)
Short-run effects				
Real price	-0.970 (0.712)	—	-1.226 (0.953)	—
Real net wages	0.907*** (0.219)	—	1.104* (0.636)	—
Adjustment dynamics				
Error-correction term	-0.936*** (0.155)	—	-0.743*** (0.106)	—

Source: Authors' own calculations

Notes: Both ARDL models include real net wages, a post-2022 structural-change dummy, and monthly dummies. IV estimates are obtained using two-stage least squares. Cigarette prices are instrumented using the specific excise tax and lagged cigarette prices, while HTP prices are instrumented using the HTP excise tax. Standard errors are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table B8. Diagnostic tests and instrument validity

Test	Cigarettes	Decision	HTPs	Decision
ARDL diagnostics				
Bounds F-statistic	12.241	Cointegration confirmed	16.757	Cointegration confirmed
Bounds t-statistic	-6.048	Cointegration confirmed	-7.026	Cointegration confirmed
Breusch–Pagan heteroskedasticity (p-value)	0.686	Homoskedastic residuals	0.670	Homoskedastic residuals
Breusch–Godfrey autocorrelation (p-value)	0.040	Mild serial correlation	0.316	No serial correlation

Test	Cigarettes	Decision	HTPs	Decision
Durbin alternative test (p-value)	0.071	No serial correlation	0.365	No serial correlation
Ramsey RESET (p-value)	0.560	Correct functional form	0.434	Correct functional form
Mean VIF	3.38	No multicollinearity concerns	2.73	No multicollinearity concerns
IV diagnostics				
Anderson LM under-identification (p-value)	<0.001	Identified	<0.001	Identified
Cragg–Donald F statistic	149.83	Strong instruments	95.62	Strong instruments
Stock–Yogo 10% critical value	19.93	Threshold exceeded	19.93	Threshold exceeded
Endogeneity test (p-value)	0.891	Price exogeneity not rejected	0.003	Price endogeneity detected
Sargan test (p-value)	0.156	Instrument validity	0.136	Instrument validity

Source: Authors' own calculations

Notes: Bounds tests reject the null hypothesis of no long-run relationship at the one-percent significance level. Cragg–Donald statistics substantially exceed Stock–Yogo critical values, indicating that weak instruments are not a concern.

Table B9. First-stage diagnostics for the baseline specification

Endogenous variable	Partial R^2 of excluded instruments	First-stage F statistic	Interpretation
Price	0.779	1116.55	Strong instruments
Price × Firm supplies both cigarettes and HTPs	0.812	1143.35	Strong instruments
Log within-group share	0.222	75.26	Strong instruments

Source: Authors' own calculations

Table B10. Nested-logit demand parameter estimates across alternative IV specifications

Variable	Baseline IV	No-tax IV	Lagged-competitor IV
Price	-0.473*** (0.147)	-0.349*** (0.126)	-0.487* (0.272)
Price × Firm supplies both cigarettes and HTPs	-0.095*** (0.016)	-0.082*** (0.016)	-0.062** (0.031)
Log within-group share (σ)	0.915*** (0.018)	0.913*** (0.019)	0.859*** (0.035)
Strong	0.026** (0.010)	0.019* (0.010)	0.021 (0.018)
Medium	-0.017** (0.008)	-0.021** (0.008)	-0.035** (0.015)
Ultralight	0.038*** (0.008)	0.035*** (0.007)	0.056*** (0.012)
Flavored	0.029 (0.038)	0.053 (0.036)	0.075 (0.069)
Long cigarette	0.004 (0.011)	0.012 (0.011)	0.023 (0.027)
Slims	0.083*** (0.017)	0.085*** (0.018)	0.136*** (0.031)
HTP light	-0.075*** (0.021)	-0.078*** (0.022)	-0.108*** (0.033)
Tobacco-flavored HTP	-0.098*** (0.023)	-0.101*** (0.024)	-0.141*** (0.039)
Menthol-flavored HTP	-0.097*** (0.024)	-0.100*** (0.024)	-0.133*** (0.036)
Dimensions HTP flavor	-0.056 (0.078)	-0.078 (0.079)	-0.184 (0.131)
Type of HTP device 1	0.255*** (0.052)	0.265*** (0.053)	0.307*** (0.066)
Type of HTP device 2	-0.051 (0.031)	-0.025 (0.031)	-0.130*** (0.041)
Type of HTP device 3	-0.310*** (0.059)	-0.282*** (0.053)	-0.437*** (0.085)
HTP product indicator	−1.606* (0.373)	-0.918*** (0.122)	-0.941*** (0.214)
Firm supplies both cigarettes and HTPs	0.256*** (0.038)	0.228*** (0.042)	0.192** (0.085)
Low-price segment	-0.378** (0.181)	-0.242 (0.151)	-0.429 (0.281)
Medium-price segment	0.550*** (0.122)	0.650*** (0.102)	0.521** (0.199)

Source: Authors' own calculations

Notes: *** p < 0.01, ** p < 0.05, * p < 0.10. Standard errors in parentheses. All specifications include market-fixed effects. The baseline specification uses excise-tax variables, product-count instruments, and rival-product characteristics. No-tax IV excludes tax instruments. Lagged-competitor IV replaces contemporaneous competitive-density measures with lagged competitor instruments. Color is used as a proxy for perceived cigarette and HTP strength**,** as packaging color often signals tar and nicotine

levels to consumers, even though scientifically they are not clearly related to the overall harm levels of these products. Darker colors are generally associated with stronger variants, while lighter colors (such as white, yellow, silver, pink, and gold) imply milder or "light" options. This color signal indicates perceived cigarette strength, especially when explicit strength labeling is not provided.

Table B11. Segment-level elasticities under alternative assumptions on market expansion

	Economy-price cigarettes	**Middle-price cigarettes**	**Premium cigarettes**	**HTP**
Economy-price cigarettes	-0.839*** (0.249)	0.352*** (0.107)	0.191 (0.155)	0.085 (0.123)
Middle-price cigarettes	0.149*** (0.045)	-0.781*** (0.234)	0.192*** (0.055)	0.082*** (0.022)
Premium cigarettes	0.148 (0.126)	0.350*** (0.106)	-0.705*** (0.409)	0.084*** (0.017)
HTPs	0.164 (0.136)	0.368*** (0.112)	0.208*** (0.060)	-1.262*** (0.347)

Source: Authors' own calculations

Notes: The table reports elasticities under an alternative assumption that continued market expansion leads to a moderate post-2022 decline (illicit shares of 22/20/18/15 percent). Additional robustness analyses based on other outside-good assumptions and alternative instrument sets yielded similar qualitative conclusions and are available from the authors upon request.