The Impact of Cigarette Prices on Smoking Initiation: Evidence from Ecuador*

Sergio Parra-Cely[ǂ]

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ǂ Corresponding author. USFQ School of Economics. Email: sparrac@usfq.edu.ec

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Abstract

Increasing tobacco prices is a popular public health measure to deter smoking onset in developing countries. I provide evidence on the effectiveness of such a policy intervention by leveraging plausible exogenous variation in tobacco prices through sudden excise tax changes in Ecuador to estimate the price elasticity of tobacco on the smoking initiation hazard. Results from discrete-time survival models suggest young people at risk of starting smoking are deterred by increased tobacco prices, although elasticity estimates are below unity (mean elasticity=-0.4). These findings suggest that large excise tax changes are necessary to successfully prevent smoking initiation among adolescents.

Keywords: tobacco prices, excise taxes, smoking initiation hazard, Ecuador.

JEL Codes: C41, H20, I12, I18.

1. Introduction

While the global risk-weighted prevalence of tobacco exposure has decreased, tobacco deaths and tobacco-related illness have remained steady or increased continuously over the last decade (Forouzanfar et al., 2016). It is thus not surprising that policy interventions aimed at increasing tobacco retail prices are considered one of the most effective ways to reduce the risk of smoking onset. The implementation of excise taxes to increase retail tobacco prices is motivated by the fact that (i) it is more cost-effective to deter potential smokers when they are young; (ii) prospective young smokers may be more price-sensitive as they have not yet developed an addiction to tobacco; and (iii) adolescents are financially constrained to start smoking or to maintain a constant rate of tobacco consumption when prices increase. However, if peer pressure or social acceptance concerns are positively correlated with tobacco consumption, young smokers may be willing to pay more for cigarettes. Moreover, illegal access to cigarettes due to tobacco smuggling may attenuate the effect of higher prices on smoking onset since illegal tobacco products are sold below the legal market value (e.g. Gruber et al., 2003).

Empirical evidence on the effects of tobacco prices on smoking onset is mixed. Several studies implementing time-series econometric techniques have identified price elasticities of youth smoking near unity. [1] However, elasticities recovered from this literature usually cannot provide any explanation for how prices affect heterogeneous segments of the population. More recent studies using cross-sectional retrospective data on smoking behaviors provide conservative estimates of smoking onset elasticities. [2] This later research also controls for regional variation in anti-smoking sentiments, as well as for the demographic heterogeneity of individuals at risk of starting to smoke (e.g. Emery et al., 2001; DeCicca et al., 2002; Cawley et al., 2004; DeCicca et al., 2008; Nonnemaker and Farrelly, 2011; Lillard et al., 2013). Most of this evidence is gathered from developed countries, in which financial constraints faced by youths may be insufficient to counterweight other determinants of smoking initiation, such as peer pressure, the demand for social acceptance, or the lack of compliant behavior during adolescence (e.g. Palali and van Ours, 2019). Studies conducted with data from low and middle income countries (LMICs) indicate that results depend on country-specific contexts, rendering elasticities above unity (e.g. Guindon, 2014; Kostova et al., 2017); other studies suggest that the smoking onset risk is inelastic to price (e.g. Kostova et al., 2015; Filby and van Walbeek, 2022). The few studies available for countries in Latin America and the Caribbean suggest a negative association between tobacco prices and smoking initiation.

However, they show that large cigarette tax increases are required to successfully deter young people from smoking (e.g. Guindon et al., 2015, 2018, 2019). This article aims at contributing to this literature, by providing cross-sectional estimates of the price elasticity of tobacco on smoking initiation hazard, using data from Ecuador.

As a country with a non-negligible prevalence of tobacco consumption, Ecuador provides a particularly relevant case to test the influence of cigarette prices on the risk of smoking initiation. [3] As part of the government's commitment to reduce cigarette consumption following its participation in the Framework Convention on Tobacco Control (FCTC), a series of sizable excise tax increments were introduced. The first policy change, in January 2008, raised the ad valorem tax by 52 percentage points from a baseline rate of 98%. The second change, in December 2011, substituted the ad valorem tax for a lump-sum tax at a rate of USD$0.08 per cigarette sold in the retail market. The unanticipated nature of such policy changes, and their orthogonality with the variation of

[1] See DeCicca et al., 2022 for a review.
[2] It is worth noting that price elasticities of youth smoking and smoking onset hazard are not necessarily comparable.
[3] As of 2021, 18% (2.7%) of males (females) aged 15 years or more reported any tobacco use (WHO, 2023).

anti-smoking sentiments at the local level, supports the plausible exogeneity of tobacco prices. This fact, combined with consumers' lack of market power to set retail prices, permits the recovery of the price elasticity of smoking onset hazard by estimating discrete-time duration models of smoking initiation.

Results from this study confirm the negative association between higher tobacco prices and the risk of smoking initiation. However, price elasticities of tobacco estimates are, with some minor exceptions, below unity. When assigning the month of birth as the month within the year individuals started smoking, price elasticities range between -0.3 and -0.8. I also observe a disproportional smoking onset hazard for males relative to female smokers, reaching a peak at 16 years old and decreasing afterwards. In contrast, no significant heterogeneity in the sensitivity to tobacco prices by different socio-demographic divides is found. Inhabiting urban areas or tobacco-producing municipalities plays a role in the effect of price elasticities on smoking initiation hazard, which is not shown to be driven by gender, ethnic background, or migration status. In line with evidence from other countries in the region, these findings support the need for "more than proportional" excise tax increases to generate an appropriate price response that would dissuade smoking initiation. [4]

I implement several robustness checks to verify my findings. Estimates are fairly consistent when alternative functional forms of the baseline hazard function are considered, when I estimate models with population weights, and when I increase the frequency of the duration model from yearly to monthly spells. As results may be sensitive to the month in which the smoking onset episode would occur, I randomly allocate the month of the onset year in which prices may (or may not) influence smoking initiation. Several trials of this simulation exercise allow me to approximate the sampling distribution of the price elasticity of tobacco under different specifications, recovering a median estimate of -0.4. All results taken together confirm that the price elasticity of the smoking initiation hazard is non-negligible, but is lower than one.

An additional contribution of this paper is to challenge the requirement to include alcohol prices in duration models as a relevant control variable, when alcohol and tobacco prices are highly correlated. Economic theory suggests that if alcoholic beverages and tobacco are complementary goods, alcohol prices are required as a control in the survival model. In the Ecuadorian case, I provide evidence that alcohol and tobacco prices are highly correlated. When alcohol is included in the model as a control variable, it induces a multicollinearity problem that hides the true effect of increased tobacco prices on the smoking initiation hazard. This evidence is particularly compelling in my simulation exercises, where the sampling distribution of the price elasticity of tobacco is centered around zero when these estimates are obtained from a duration model in which both tobacco and alcohol prices are included as regressors.

The remainder of this paper is as follows. Section 2 discusses data sources and the construction of the event-story data set. Section 3 presents the empirical strategy and identification assumptions. Section 4 documents the findings, including heterogeneity effects and sensitivity check analyses. Section 5 concludes.

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[4] Studies using store-level scanner data recover pass-through effects of up to 0.8 (e.g. Harding et al., 2012; Chiou and Muehlegger, 2014). Other studies indicate that the full inuence of excise taxes on retail tobacco prices is prevalent only for non-daily smokers, less addicted smokers, and smokers of light cigarettes (DeCicca et al., 2013).

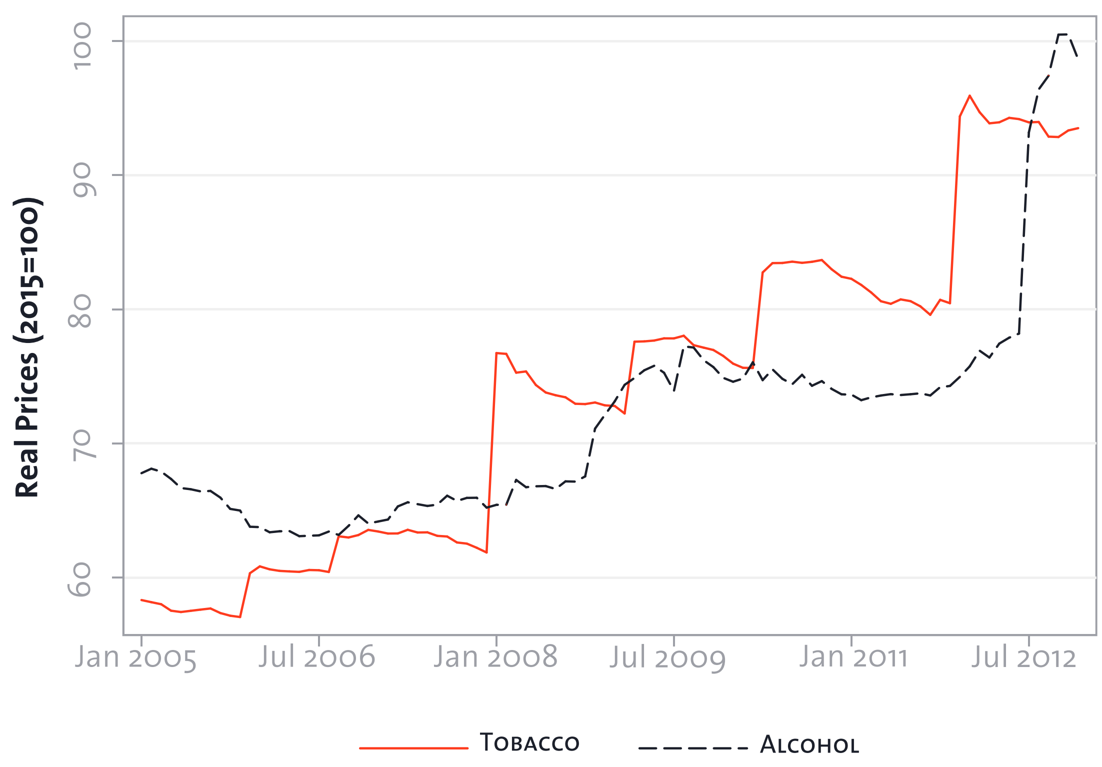
2. Data Overview

2.1 Data on Prices

To source data on nominal alcohol and tobacco prices, I use the manufactured components of Ecuador's consumer price index (CPI), available from January 2005 to December 2012, reported by Ecuador's National Statistical Agency (INEC, hereafter). Information prior to 2005 is not available as INEC did not report the CPI for individual categories until 2005. To express prices in real quantities, I deflated nominal prices using the general CPI at the national level.

Figure 1 displays the change in real tobacco and alcohol prices since January 2005. At least two structural changes in tobacco prices are worth discussing. The first occurs in January 2008, where the tobacco excise tax increased from an ad valorem tax of 98% to a 150% rate per cigarette sold, leading to a 28% retail price increase. The second price jump occurred in December 2011, when a 150% ad valorem tax was substituted for a lump sum tax of USD$0.08 per cigarette sold, resulting in an additional 24% price increase relative to baseline values prior to 2008. [5] Alcohol prices display a smoother positive change until November 2011, when the Ecuadorian government imposed a lump sum tax of USD$6.20 per liter of alcohol sold. Overall, both price series exhibit a significant positive correlation across the entire period of analysis (Pearson's coefficient=0.79).

Figure 1: Inflation-Adjusted Manufactured Tobacco and Alcohol Prices



Source: Consumer Price Index, all categories, published by the Ecuadorian National Statistical Agency (INEC).

[5] Changes in excise taxes were issued as presidential decrees one month before they were binding. For example, the January 2008 ad valorem tax change decree was issued on December 29, 2007 (Ley de regimen tributario interno, Art. 82). All tobacco tax changes were legally binding at the national level.

2.2 Data on Individuals and their Smoking Behaviors

The primary source of information for this analysis is the first wave (2012) of the National Survey of Health and Nutrition (ENSANUT, hereafter), conducted by INEC. This survey collects data on health indicators, health risk factors, infant and child malnutrition, sexual and reproductive health, and other socioeconomic characteristics among a nationally representative cross-sectional sample of households with members aged 5-60 years old. While this survey was also conducted in 2018, I use the first wave since the module of health risk indicators and smoking behaviors was discontinued in 2018, with a very limited version of this module only conducted among respondents aged 5-17 years old in that year.

For this study, the selected sample consists of men and women born between January 1972 and December 1994, aged 18-40 at the time of data collection. This sample selection corresponds to the pool of individuals that may have initiated smoking between January 2005 and December 2012, inside the age-at-risk period window assumed to be between 13 to 33 years old. While many studies assume the start of smoking initiation risk at age zero, there is a large heterogeneity in the age window used to model the baseline hazard as a function of age. In this case, the age-window decision is merely data-driven. However, I try to use an age window that aligns with the ones used in other studies. [6] I collect information on time-invariant, predetermined socioeconomic characteristics such as gender, ethnicity, region of residence, and whether the individual lives in a rural or urban area. While other socioeconomic attributes correlated with smoking onset are available, such as education level and income, I exclude these since their retrospective time variation cannot be recovered from the cross-sectional nature of the data.

I use the ENSANUT health risk indicators and behaviors module for data on smoking initiation behaviors. This module collected data on whether respondents had consumed at least one cigarette during their lifetime and, if so, the age they first smoked a cigarette. Smoking initiation is dened as the transition from being a never-smoker to becoming an ever-smoker. Thus, I create an individual-period dataset based on the age the respondent might have initiated cigarette consumption. The smoking onset indicator variable takes a value zero if the individual did not smoke in that period, and a value of one otherwise. Each ever-smoker contributes no observations in all subsequent periods a smoking initiation event was reported.

Ever-smokers contribute no further information for subsequent periods in which a smoking event was reported. Never-smokers provide observations for each period-at-risk that can be matched with the available tobacco prices during the age-at-risk window. In practice, this implies that the final dataset used in this study corresponds to a censored event-story format with right and left truncation.

The periodicity of the event-story dataset requires further discussion. First, I present estimates in which a period at risk is dened on a yearly basis. Second, I present results with an extended version of this data set in which I assume a monthly frequency. In both cases, prices are matched by the month of birth within each year-at-risk of smoking initiation. [7] In subsequent robustness checks, instead of assuming arbitrarily a month in which all ever

[6] For instance, DeCicca et al. (2002) uses a lower bound of 13 years old, while Lillard et al. (2013) uses a 27 years upper bound. My estimates remain robust when implementing a 10-33 years age window, and are available upon request.

[7] This implies assuming that all individuals are at risk of starting cigarettes consumption in their month of birth.

smokers could initiate tobacco consumption, I run 1,000 trials in which a random month per individual-year is drawn. Next, I add data on prices for the selected month, to then estimate different specifications of the discrete-time duration model. This exercise allows me to approximate the sampling distribution of the tobacco price elasticity, as well the sensitivity of these estimates to the month in which the smoking initiation may occur (refer to the robustness checks section for further details).

2.3 Other Sources of Information

To account for other non-price related, time-varying determinants of smoking initiation, I created binary variables taking a value of one after June 2006 to account for the period Ecuador ratified its FCTC participation. This time-varying control is included to proxy for regulatory measures aimed at dissuading tobacco consumption other than excise taxes (e.g. banning tobacco advertising, banning smoking in public spaces). Finally, to proxy anti-smoking sentiment, I obtain data on tobacco production at the municipal level from INEC's 2000 National Agricultural Census (CNA). Since tobacco production is highly dependent on agricultural and climate conditions which remained invariant during the period of interest, I consider the distribution of tobacco production in 2000 a good proxy for spatially heterogeneous attitudes towards tobacco consumption.

3. Empirical Strategy

I model smoking onset with a discrete time hazard model that assumes the probability of initiation to depend on an unobserved latent variable, usually interpreted as the propensity to start smoking, following previous contributions to the literature (e.g. Nonnemaker and Farrelly, 2011; Guindon et al., 2018). I assume that the relationship between smoking initiation propensity, prices, and other individual observable and unobservable characteristics can be described with a complementary log-log specification (cloglog):

$$log\,[-log\,(1 - P_{imt})] = \beta_0 + \beta_1\, PriceTobacco_t + \gamma\, X_{imt} + f\,(t;\theta) \qquad (1)$$

Where P_{imt} denotes the probability of smoking initiation for individual *i*, living in municipality *m* in period *t*, conditional on not having consumed tobacco until period *t–1*. Tobacco prices, denoted by $PriceTobacco_t$, are expressed in natural logarithms. Hence, parameter β_1 represents the price elasticity of the smoking initiation hazard. Individual-specific, time-invariant attributes are included in the vector X_{imt} with associated vector coefficients γ . Finally, $f\,(t;\theta)$ accounts for the baseline hazard function. In my preferred specification, I use a cubic polynomial specification. For robustness checks, other flexible approaches are considered, such as the inclusion of a cubic spline function, and the inclusion of age-at-risk specific dummies. Moreover, I include a set of ve-year interval binary variables to control for variation in the calendar year that respondents were first exposed to the risk of smoking initiation, as suggested by Kom et al. (1997). The choice of the cloglog specification is justified by the fact that it has a response curve that is asymmetric, which is better suited to models with censored observations, i.e. never-smokers at the time of the survey interview, and few failures, i.e. few ever-smokers in the sample (Box-Steffensmeier and Jones, 2004).

Identification of the price elasticity β_1 is obtained by assuming that (i) no private tobacco consumption has enough influence to affect the market price; and (ii) increases in cigarette prices through excise taxes are not driven by unobserved confounders correlated with tobacco consumption, such as anti-smoking sentiments. While defending the first assumption is straightforward, the second assumption is supported by the nationally induced changes in tobacco prices. It is worth noting that changes in excise taxes in Ecuador were neither anticipated nor geographically (locally) motivated. Given that the price measures considered in this study were constructed from retail prices, and do not depend on average self-reported measures, it is safe to assume that tobacco prices are plausibly exogenous.

4. Results

4.1 Descriptive Statistics

Summary statistics are reported in Table 1. Nearly 74% of survey respondents are women, as the 2012 ENSANUT survey wave over-sampled female respondents for its sexual and reproductive health modules. 80% of respondents self-identify as white or mestizos. One percent of respondents declared that they migrated to Ecuador at some point in their lives. 42% of respondents live in rural areas, and at least 56% of individuals have access to all sanitation services (tap water, sewage, garbage disposal networks). Nearly 50% of respondents live in the Andean region. On average, in the event-story dataset with yearly frequency, an individual is observed during six-year spells. 23% of respondents declared they had smoked at least one cigarette during their lifetime, and 7% declared that they continued smoking. Similar figures are observed when splitting the sample by residence in tobacco-producing municipalities. Males present higher smoking consumption rates (51%) than females (13%) and show less propensity to quit smoking.

Regarding the age of smoking onset, Figure 2 displays the Kaplan-Meier product-limit survivor and hazard functions for both males and females, assuming that individuals were exposed to the risk of smoking initiation at age 13. Even though, on average, men and women start smoking at a similar age (16 years old), both figures suggest substantial differences in smoking onset risk by gender. In addition, hazard rates present a non-monotonic evolution, suggesting that a complementary log-log specification is an appropriate choice to approximate the functional form of the baseline hazard function.

4.2 Main Results

Table 2 presents the main results of the discrete-time complementary log-log (cloglog) duration models. All specifications include a cubic polynomial function to approximate the baseline hazard function, as well as five-year interval dummies to account for differences in the calendar years individuals were first-exposed to the risk of smoking initiation, as suggested by Kom et al. (1997). The first two columns report estimates where the event-story data are set on a yearly frequency. The remaining columns report coefficients where the event-story data were expanded to account for a monthly frequency. Prices are matched by the month of birth per each year at risk. Robust standard errors are reported in parentheses, and clustered at the individual level.

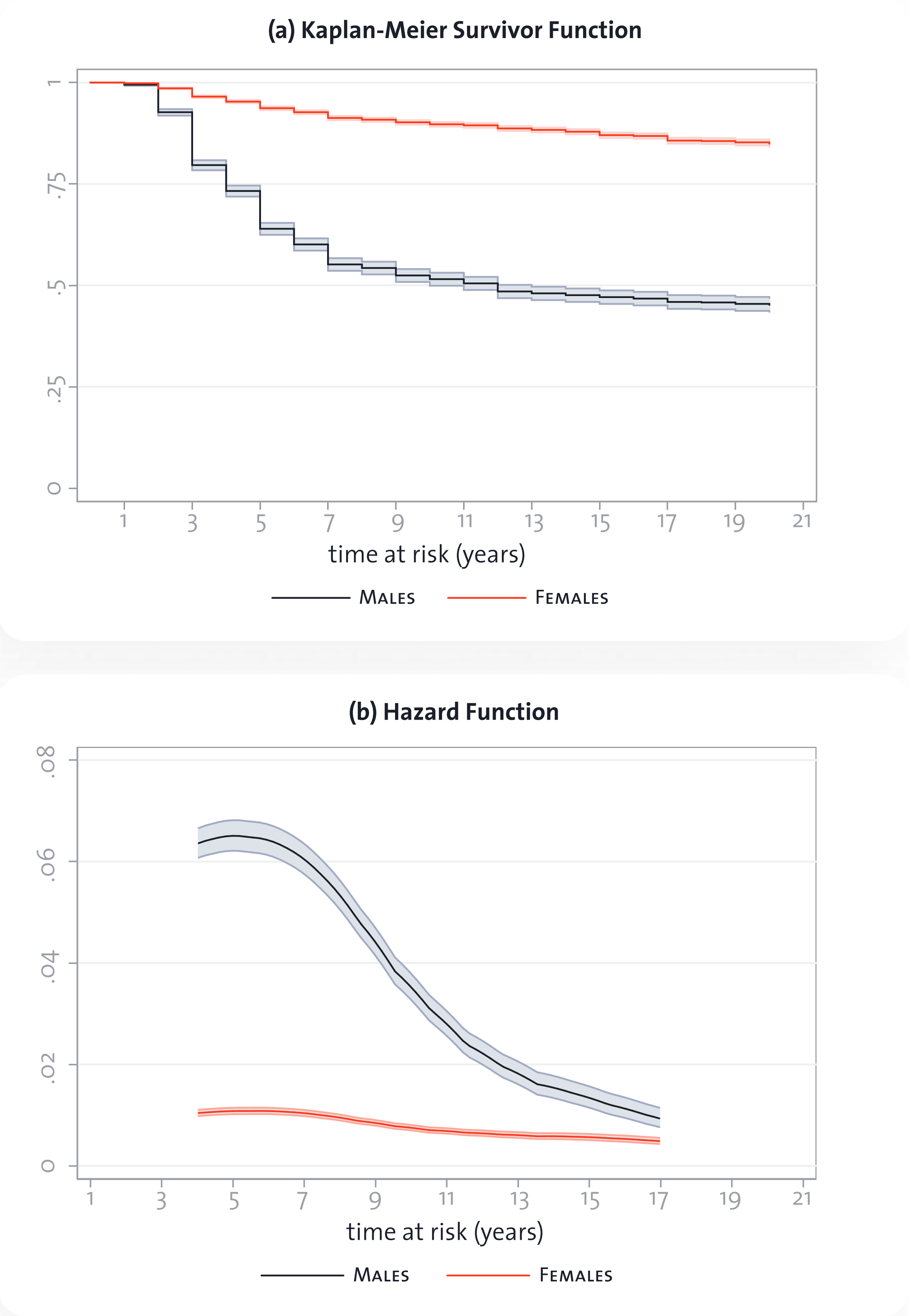
In the most parsimonious specifications, price elasticities of the smoking onset hazard suggest that a one percent increase in tobacco prices induces a reduction of up to 0.37% in the hazard rate (Columns 1 and 3). After including covariates and other time-varying determinants of smoking initiation, the price elasticity of the smoking initiation hazard increases up to -0.84, 1.3 times higher, in absolute value, than the coefficient obtained in the specification that includes without control variables (Columns 2 and 4). Irrespective of the frequency used for the event-story data, estimates for the most conservative specifications are fairly comparable as their 95% confidence intervals overlap.

Table 1: Summary Statistics ENSANUT 2012 Sample

	(1) Full Sample	(2) Tobacco Production	(3) No Tobacco Production	(4) Males	(5) Females
female	0.74 (0.44)	0.74 (0.44)	0.71 (0.45)		
Age at interview (years)	27.59 (6.58)	27.58 (6.60)	27.63 (6.47)	24.87 (6.03)	28.55 (6.50)
Indigenous	0.13 (0.34)	0.14 (0.35)	0.08 (0.27)	0.11 (0.31)	0.14 (0.34)
Afroecuatorian/Black	0.04 (0.20)	0.04 (0.20)	0.05 (0.21)	0.05 (0.21)	0.04 (0.19)
Montubio	0.03 (0.18)	0.03 (0.17)	0.05 (0.22)	0.04 (0.20)	0.03 (0.17)
White and/or mestizo	0.80 (0.40)	0.79 (0.41)	0.82 (0.38)	0.80 (0.40)	0.79 (0.40)
Former migrant	0.01 (0.11)	0.01 (0.12)	0.00 (0.06)	0.01 (0.10)	0.01 (0.12)
Rural household	0.42 (0.49	0.44 (0.50)	0.27 (0.44)	0.40 (0.49)	0.42 (0.49)
Access to tap water	0.79 (0.41)	0.80 (0.40)	0.70 (0.46)	0.78 (0.41)	0.79 (0.41)
Access to sewage network	0.56 (0.50)	0.57 (0.50)	0.50 (0.50)	0.56 (0.50)	0.56 (0.50)
Access to waste management network	0.81 (0.39)	0.80 (0.40)	0.85 (0.36)	0.83 (0.38)	0.80 (0.40)
Andean region	0.46 (0.50)	0.48 (0.50)	0.36 (0.48)	0.41 (0.49)	0.48 (0.50)
Coastal region	0.26 (0.44)	0.22 (0.42)	0.48 (0.50)	0.33 (0.47)	0.24 (0.43)
Amazon region	0.25 (0.43)	0.27 (0.44)	0.16 (0.37)	0.22 (0.42)	0.26 (0.44)
Galapagos islands	0.03 (0.16)	0.03 (0.17)	0.00 (0.00)	0.03 (0.17)	0.02 (0.15)
Number of spells	5.99 (2.41)	5.98 (2.42)	6.04 (2.38)	5.00 (2.47)	6.33 (2.30)
Ever smoked	0.23 (0.42)	0.23 (0.42)	0.24 (0.42)	0.51 (0.50)	0.13 (0.34)
Smoked in the last month	0.07 (0.26)	0.08 (0.26)	0.06 (0.24)	0.22 (0.41)	0.02 (0.14)
N. individuals	15,968	13,358	2,610	4,167	11,801

Notes: Standard deviations reported in parentheses. Source: ENSANUT Survey 2012, administered by the Ecuadorian National Statistical Agency (INEC).

Figure 2: Survivor and Hazard Functions for Smoking Initiation (Starting Risk: Age 13)



Source: ENSANUT Survey 2012, administered by the Ecuadorian National Statistical Agency (INEC).

With regard to the association between individual characteristics and the hazard of smoking initiation, results suggest that belonging to an ethnic minority group is negatively correlated with smoking initiation risk. The smoking onset hazard is 75% lower for females than for males. Individuals in rural households exhibit a 22% lower risk of starting to smoke than those in urban households. Individuals living in the Amazon and Galapagos regions are at a higher risk of initiating tobacco consumption than those living in the Coastal and Andean regions. Surprisingly, the Ecuadorian government's ratification of the FCTC agreement seems to be positively correlated with the smoking onset risk. However, this result may just reflect the reverse causality mechanism, where Ecuadorians' increasing risk of smoking initiation induced the government's participation in the FCTC. [8]

To observe how the hazard of smoking initiation correlates with age and gender, in Figure 3 I present the estimated hazards of smoking initiation assuming individuals face such risk since age 13. Estimates are recovered from the discrete-time cloglog model under a yearly frequency, where all covariates and dummy variables from the most conservative specifications are included. To account for variations of the hazard explained by differences in age-at-risk, instead of using a cubic polynomial function, I include the set of binary variables by age-at-risk to estimate the baseline hazard at each age bracket. This shows that men are disproportionately exposed to a higher risk of smoking initiation compared to women, conditional on age. For instance, 16-year-old men are 27% more likely to initiate cigarette consumption, and 19 percentage points more likely to initiate smoking than women of the same age. A second peak is identified at 18 years old, when men and women are 22% and 6% more likely to initiate tobacco consumption, respectively. After that, the hazard of smoking onset rapidly declines. Overall, these findings suggest that the estimation sample covers the age range of greatest smoking hazard for both men and women.

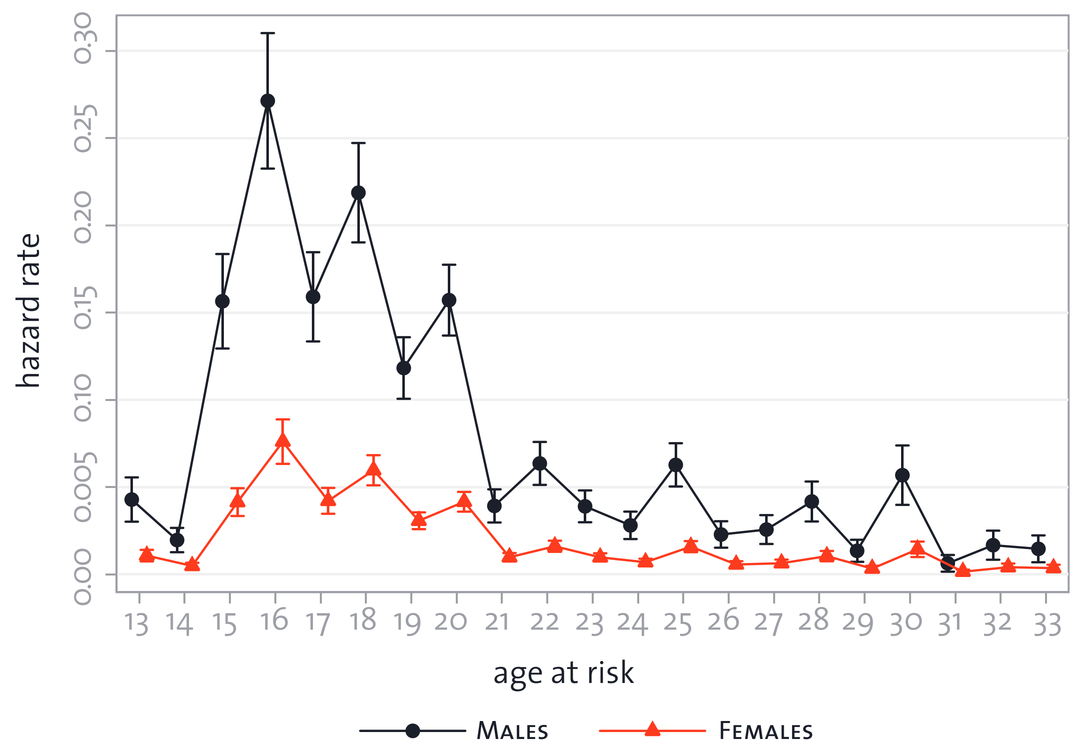
[8] I ran discrete-time duration models in which I excluded the FCTC indicator variable, and the results remain robust. These estimations are available upon request.

Table 2: Discrete-Time Complementary Log-Log Duration Models of Smoking Initiation

	Yearly Frequency		Monthly Frequency	
	(1)	(2)	(3)	(4)
Price tobacco (log)	-0.3200* (0.1753)	-0.8495*** (0.1919)	-0.3732** (0.1705)	-0.8531*** (0.1858)
1=Female		-1.4173*** (0.0357)		-1.4157*** (0.0357)
1=Indigenous		-0.3964*** (0.0579)		-0.4006*** (0.0577)
1=Afroecuatorian/black		-0.2727*** (0.0947)		-0.2745*** (0.0944)
1=Montubio		-0.1061 (0.1086)		-0.1026 (0.1085)
1=Former migrant		-0.0086 (0.1655)		0.0012 (0.1655)
1=Rural household		-0.3047*** (0.0365)		-0.3021*** (0.0365)
1=Coastal region		-0.2934*** (0.0439)		-0.2929*** (0.0438)
1=Amazon region		0.1567*** (0.0415)		0.1546*** (0.0414)
1=Galapagos region		0.1945** (0.0983)		0.1870* (0.0977)
1=FCTC		0.2673*** (0.0477)		0.2559*** (0.0483)
Intercept	-37.3613*** (1.4763)	-38.7875*** (1.5313)	-5.9526*** (0.0983)	-5.7171*** (0.1244)
Observations	95,607	95,607	1,111,191	1,111,191
N. individuals	15,968	15,968	15,968	15,968
Log-likelihood	-13,906.97	-12,983.98	-22,831.53	-21,911.77

Notes: this table presents the baseline results of the discrete-time complementary log-log (cloglog) duration models without sampling weights. All specifications include a cubic polynomial function to approximate the baseline hazard function, as well as ve-year intervals dummies to account for differences in the calendar years individuals were first exposed to the risk of smoking initiation, as suggested by Korn, Graubard, and Midthune (1997). The first two columns report estimates when the event story dataset is set on a yearly frequency. The remaining columns report coefficients in which the event story data were expanded to account for a monthly frequency. Robust standard errors are reported in parentheses and clustered at the individual level. Source: ENSANUT 2012 administered by the Ecuadorian National Statistical Agency INEC. * p.value < 0.1, ** p.value < 0.05, *** p.value < 0.01.

Figure 3: Estimated Hazard of Smoking Initiation by Gender and Age at Risk

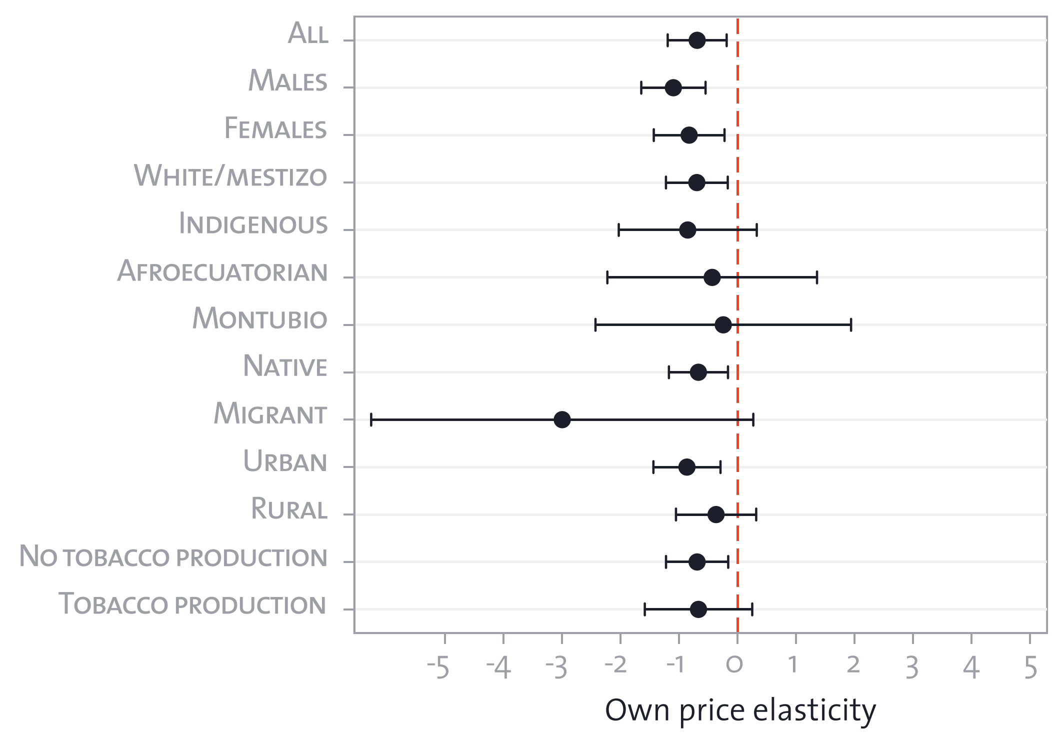


Notes: This figure displays 95% confidence intervals estimates of the baseline hazard rate by age at risk from a discrete-time complementary log-log (cloglog) model with age-at-risk specific dummies. Source: ENSANUT Survey 2012, administered by the Ecuadorian National Statistical Agency INEC.

4.3 Heterogeneity Effects Analyses

Figure 4 displays the 95% confidence interval estimates of models that examine the difference in the effects of tobacco prices on smoking onset across various socio-demographic divides. Estimates are obtained by running separate regressions in which prices are interacted in turn with each of the categories of interest to test, such as gender, ethnic self-identification, former migration status, living in rural areas or in tobacco producing municipalities. With regard to the own-price elasticity, results indicate that males and females are similarly responsive to a tobacco price increase. In contrast, price effects for ethnic minority groups are not statistically different from zero. The effect for the entire sample does not differ with the effect obtained for non-migrant individuals, while the effect for respondents who migrated to Ecuador from other countries is higher in magnitude, but imprecisely estimated. Finally, individuals living in urban areas, or non-tobacco producing municipalities seem to drive the responsiveness of smoking onset risk when tobacco prices increase.

Figure 4: Heterogeneity Effects Analyses



Notes: This figure displays 95% confidence intervals estimates of the price elasticity of tobacco and alcohol on the smoking initiation hazard by socio-demographic divides. Source: ENSANUT Survey 2012, administered by the Ecuadorian National Statistical Agency INEC.

4.4 Sensitivity Analyses

4.4.1 Alternative Functional Forms of the Baseline Hazard Function

Table A2 presents robustness check results where I propose alternative versions of the functional form of the baseline hazard function. All specifications include the list of covariates and binary variables of the most conservative models presented as main results (Table 2). Columns (1) and (4) report tobacco price elasticities when a cubic polynomial on time-at-risk is adjusted, for reference purposes. The remaining specifications present elasticities either when a cubic spline function is used (columns 2 and 5), or when a set of age-at-risk specific dummies is included (columns 3 and 6). With the notable exception of the discrete-time duration model with age-at-risk dummies under a monthly frequency, all estimates present similar magnitudes and statistical significance. Coefficients reported in column (6) present abnormally higher price elasticities, suggesting that baseline results, as well as the coefficients obtained under different functional forms and data frequency, might be interpreted as lower bound estimates. [9]

[9] In appendix table A3 I present the same results including alcohol prices as an additional regressor. Results remain qualitatively similar to those reported in this subsection.

Figure A1 and Table A8 in the appendix display the sampling distributions under different scenarios, and their descriptive statistics, respectively. When alcohol prices are excluded from the model, as in the preferred model, the price elasticity of tobacco on smoking onset hazard ranges between -0.06 to -0.737, with a median value of -0.4. These elasticity estimates lie in the range estimated in the literature for other Latin American countries. In addition, the upper limit of the sampling distribution is similar to the estimate provided under the assumption that ever-smokers started smoking in the first month of their smoking onset year.

In contrast, when performing the same simulation exercise including alcohol prices, the price elasticity of tobacco is imprecisely estimated. Estimated values range between -0.52 and 0.71, with a median value of 0.18. The standard error of the estimation is 0.184, which is twice as high as the standard error from the models ignoring alcohol prices. Overall, these results suggest that, in the presence of a positive correlation between alcohol and tobacco prices, it might be best to exclude the former to obtain more precise estimates of the price elasticity of tobacco on the smoking onset hazard.

5. Conclusion

In this study, I have documented the non-negligible, but still inelastic, response of prospective smokers to increased tobacco prices. Estimates from several discrete-time duration models of smoking onset indicate that elasticity magnitudes are sensitive to the period in which smoking initiation may occur, as well as whether tobacco and alcohol prices are positively correlated. Nonetheless, the price elasticities obtained in this study are in line with other studies from the Latin American region, supporting the need for substantial excise tax increments to generate an adequate response in preventing smoking initiation among the youth.

From a global public policy perspective, this study provides evidence on the effectiveness of raising tobacco prices to deter and/or delay smoking initiation, contradicting conclusions of some comprehensive meta-analyses (e.g.Guindon, 2013). My results are in line with the literature for Latin America and the Caribbean which shows that cigarette prices have a negative and significant effect on tobacco consumption (e.g. Guindon et al., 2015). The Ecuadorian experience can provide valuable lessons for governments of similar LMICs on how unanticipated excise tax increases are useful in affecting smoking initiation decisions, even where cigarette smuggling and lack of minimum-age law enforcement may weaken the pass-through mechanism between taxes and retail prices. [10] Given that most of the price elasticities recovered under various estimation scenarios lie below one, a direct implication for public policy design is that substantial (i.e. more than proportional) cigarette tax increases are necessary to optimally deter smoking initiation.

It is important to note that the present research has some limitations. First, measures of cigarette and alcohol prices represent mean price changes over time across different brands and categories. This limitation is particularly relevant for younger respondents, as evidence suggests that this group invests in more expensive

[10] Further, new evidence suggests that the role of cigarette smuggling in weakening the deterrent effect of prices has been exaggerated by the tobacco industry (e.g. Paraje et al., 2023).

varieties of cigarettes unlike adult consumers (DeCicca et al., 2022). Second, this study may suffer from recall bias, by using cross-sectional self-reported data to reconstruct smoking histories. This could result in measurement error in the dependent variable. I expect this bias to be more prominent for older smokers. If anything, estimates obtained with younger samples suggest that any recall bias may be attenuating the true price elasticity effect (Kenkel et al., 2004). [11] Third, the use of cross-sectional retrospective data means I could not control for time-varying determinants of smoking initiation, such as income, health, time preferences, or peer pressure. To circumvent these constraints, it would be useful to implement a longitudinal follow-up study of youngsters at risk to replicate the duration analysis implemented with cross-sectional data, as well as to investigate whether tobacco price increases can accelerate smoking cessation at early stages of the life cycle. I consider these questions as promising areas for future research.

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Appendix Tables and Figures

Table A1: Discrete-Time Complementary Log-Log Duration Models of Smoking Initiation: Including Alcohol Prices

	Yearly Frequency		Monthly Frequency	
	(1)	(2)	(3)	(4)
Price tobacco (log)	0.0277 (0.2124)	-0.6963*** (0.2571)	-0.0770 (0.2027)	-0.7452*** (0.2419)
Price alcohol (log)	-0.8130*** (0.2689)	-0.2885 (0.2958)	-0.7161*** (0.2641)	-0.2110 (0.2854)
1=Female		-1.4175*** (0.0357)		-1.4158*** (0.0357)
1=Indigenous		-0.3964*** (0.0579)		-0.4006*** (0.0577)
1=Afroecuatorian/black		-0.2725*** (0.0946)		-0.2745*** (0.0943)
1=Montubio		-0.1062 (0.1085)		-0.1026 (0.1084)
1=Former migrant		-0.0089 (0.1655)		0.0010 (0.1655)
1=Rural household		-0.3047*** (0.0365)		-0.3021*** (0.0364)
1=Coastal region		-0.2934*** (0.0439)		-0.2929*** (0.0438)
1=Amazon region		0.1568*** (0.0415)		0.1546*** (0.0414)
1=Galapagos region		0.1945** (0.0983)		0.1870* (0.0977)
1=FCTC		0.2508*** (0.0522)		0.2439*** (0.0524)
Intercept	-37.7305*** (1.4802)	-38.8665*** (1.5259)	-6.1188*** (0.1166)	-5.7482*** (0.1290)
Observations	95,607	95,607	1,111,191	1,111,191
N. individuals	15,968	15,968	15,968	15,968
Log-likelihood	-13,903.90	-12,983.64	-22,829.15	-21,911.59

Notes: this table presents the baseline results of the discrete-time complementary log-log (cloglog) duration models without sampling weights. All specifications include a cubic polynomial function to approximate the baseline hazard function, as well as five-year interval dummies to account for differences in the calendar years individuals were first-exposed to the risk of smoking initiation, as suggested by Korn, Graubard, and Midthune (1997). The rst three columns report estimates when the event story dataset is set on a yearly frequency. The remaining columns report coefficients in which the event story data were expanded to account for a monthly frequency. Robust standard errors are reported in parentheses and clustered at the individual level. Source: ENSANUT 2012 administered by the Ecuadorian National Statistical Agency (INEC). * p.value < 0.1, ** p.value < 0.05, *** p.value < 0.01.

Table A2: Discrete-Time Complementary Log-Log Duration Models of Smoking Initiation: Alternative Functional Forms

	Yearly Frequency			Monthly Frequency		
	(1)	(2)	(3)	(4)	(5)	(6)
Price tobacco (log)	-0.8495*** (0.1919)	-0.9318*** (0.1963)	-1.1249*** (0.2065)	-0.8391*** (0.1834)	-0.9429*** (0.1884)	-3.1688*** (0.1948)
Cubic polynomial	yes	no	no	yes	no	no
Cubic spline	no	yes	no	no	yes	no
Age-at-risk dummies	no	no	yes	no	no	yes
Observations	95,607	95,607	95,607	1,111,191	1,111,191	1,111,191
N. individuals	15,968	15,968	15,968	15,968	15,968	15,968
Log-likelihood	-12,983.98	-12,911.95	-12,572.69	-21,928.90	-21,856.69	-21,340.47

Notes: this table presents the baseline results of the discrete-time complementary log-log (cloglog) duration models. All specifications include the list of covariates as of Table 2, as well as five-year intervals dummies to account for differences in the calendar years individuals were first exposed to the smoking initiation hazard, as suggested by Korn, Graubard, and Midthune (1997). The first three columns report estimates when the event story dataset is set on a yearly frequency. The remaining columns report coefficients in which the event story data were expanded to account for a monthly frequency. Robust standard errors are reported in parentheses and clustered at the individual level. Source: ENSANUT 2012 administered by the Ecuadorian National Statistical Agency INEC. * p.value < 0.1, ** p.value < 0.05, *** p.value < 0.01.

Table A3: Discrete-Time Complementary Log-Log Duration Models of Smoking Initiation: Alternative Functional Forms (Including Alcohol Prices)

	Yearly Frequency			Monthly Frequency		
	(1)	(2)	(3)	(4)	(5)	(6)
Price tobacco (log)	-0.6922*** (0.2572)	-0.7702*** (0.2605)	-0.8446*** (0.2686)	-0.7431*** (0.2418)	-0.8427*** (0.2441)	-2.3926*** (0.2572)
Price alcohol (log)	-0.2879 (0.2958)	-0.2974 (0.2995)	-0.5257* (0.3054)	-0.2090 (0.2853)	-0.2068 (0.2889)	-1.5142*** (0.3189)
Cubic polynomial	yes	no	no	yes	no	no
Cubic spline	no	yes	no	no	yes	no
Age-at-risk dummies	no	no	yes	no	no	yes
Observations	95,607	95,607	95,607	1,111,191	1,111,191	1,111,191
N. individuals	15,968	15,968	15,968	15,968	15,968	15,968
Log-likelihood	-12,980.57	-12,908.45	-12,568.57	-21,908.75	-21,843.64	-21,319.00

Notes: this table presents the baseline results of the discrete-time complementary log-log (cloglog) duration models. All specifications include the list of covariates as of Table 2, as well as five-year intervals dummies to account for differences in the calendar years individuals were first exposed to the smoking initiation hazard, as suggested by Korn, Graubard, and Midthune (1997). The first three columns report estimates when the event story dataset is set on a yearly frequency. The remaining columns report coefficients in which the event story data were expanded to account for a monthly frequency. Robust standard errors are reported in parentheses and clustered at the individual level. Source: ENSANUT 2012 administered by the Ecuadorian National Statistical Agency INEC. * p.value < 0.1, ** p.value < 0.05, *** p.value < 0.01.

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Table A4: Discrete-Time Complementary Log-Log Duration Models of Smoking Initiation: Estimates with Sampling Weights

	Yearly Frequency		Monthly Frequency	
	(1)	(2)	(3)	(4)
Price tobacco (log)	-0.3939 (0.2446)	-0.9804*** (0.2681)	-0.4500* (0.2379)	-0.9595*** (0.2606)
1=Female		-1.2974*** (0.0501)		-1.2966*** (0.0502)
1=Indigenous		-0.7105*** (0.1047)		-0.7154*** (0.1057)
1=Afroecuatorian/black		-0.2735** (0.1249)		-0.2771** (0.1250)
1=Montubio		-0.2027* (0.1198)		-0.2014* (0.1199)
1=Former migrant		0.0912 (0.2116)		0.0879 (0.2097)
1=Rural household		-0.2922*** (0.0492)		-0.2882*** (0.0491)
1=Coastal region		-0.3500*** (0.0532)		-0.3463*** (0.0532)
1=Amazon region		0.0718 (0.0467)		0.0709 (0.0466)
1=Galapagos region		0.1247 (0.1006)		0.1173 (0.1002)
1=FCTC		0.2740*** (0.0692)		0.2587*** (0.0705)
Intercept	-36.4180*** (2.1783)	-37.1688*** (2.2675)	-6.0167*** (0.1429)	-5.7522*** (0.1830)
Observations	95,607	95,607	1,111,191	1,111,191
N. individuals	15,968	15,968	15,968	15,968
Log-likelihood	-2,471,032.01	-2,325,970.53	-4,078,300.11	-3,933,482.59

Notes: this table presents the baseline results of the discrete-time complementary log-log (cloglog) duration models with sampling weights. All specifications include a cubic polynomial function to approximate the baseline hazard function, as well as five-year intervals dummies to account for differences in the calendar years individuals were first-exposed to the risk of smoking initiation, as suggested by Korn, Graubard, and Midthune (1997). The first three columns report estimates when the event story dataset is set on a yearly frequency. The remaining columns report coefficients in which the event story data were expanded to account for a monthly frequency. Robust standard errors are reported in parentheses and clustered at the individual level. Source: ENSANUT 2012 administered by the Ecuadorian National Statistical Agency (INEC). * p.value < 0.1, ** p.value < 0.05, *** p.value < 0.01.

Table A5: Weighted Discrete-Time Complementary Log-Log Duration Models of Smoking Initiation: Estimates Including Alcohol Prices

	Yearly Frequency		Monthly Frequency	
	(1)	(2)	(3)	(4)
Price tobacco (log)	-0.0403 (0.3028)	-0.8532** (0.3637)	-0.1480 (0.2886)	-0.8505** (0.3425)
Price alcohol (log)	-0.8255** (0.3954)	-0.2398 (0.4254)	-0.7282* (0.3857)	-0.2126 (0.4088)
1=Female		-1.2975*** (0.0501)		-1.2967*** (0.0502)
1=Indigenous		-0.7107*** (0.1047)		-0.7153*** (0.1057)
1=Afroecuatorian/black		-0.2734** (0.1249)		-0.2771** (0.1250)
1=Montubio		-0.2030* (0.1198)		-0.2015* (0.1198)
1=Former migrant		0.0912 (0.2118)		0.0878 (0.2097)
1=Rural household		-0.2920*** (0.0492)		-0.2882*** (0.0491)
1=Coastal region		-0.3498*** (0.0532)		-0.3463*** (0.0532)
1=Amazon region		0.0719 (0.0467)		0.0710 (0.0466)
1=Galapagos region		0.1246 (0.1006)		0.1173 (0.1001)
1=FCTC		0.2603*** (0.0744)		0.2466*** (0.0751)
Intercept	-36.7646*** (2.1936)	-37.2288*** (2.2642)	-6.1845*** (0.1704)	-5.7833*** (0.1900)
Observations	95,607	95,607	1,111,191	1,111,191
N. individuals	15,968	15,968	15,968	15,968
Log-likelihood	-2,470,468.18	-2,325,929.65	-4,077,856.18	-3,933,449.85

Notes: this table presents the baseline results of the discrete-time complementary log-log (cloglog) duration models with sampling weights. All specifications include a cubic polynomial function to approximate the baseline hazard function, as well as five-year intervals dummies to account for differences in the calendar years individuals were first-exposed to the risk of smoking initiation, as suggested by Korn, Graubard, and Midthune (1997). The first three columns report estimates when the event story dataset is set on a yearly frequency. The remaining columns report coefficients in which the event story data were expanded to account for a monthly frequency. Robust standard errors are reported in parentheses and clustered at the individual level. Source: ENSANUT 2012 administered by the Ecuadorian National Statistical Agency (INEC). * p.value < 0.1, ** p.value < 0.05, *** p.value < 0.01.

Table A6: Discrete-Time Complementary Log-Log Duration Models of Smoking Initiation: Results by Age Cohorts

	Yearly Frequency			Monthly Frequency		
	Ages 18-24 (1)	Ages 25-33 (2)	Ages 34-41 (3)	Ages 18-24 (4)	Ages 25-33 (5)	Ages 34-41 (6)
Price tobacco (log)	-1.5547***	0.1874	0.6425	-4.1818***	-2.9397***	-2.2887
	(0.3265)	(0.6248)	(1.5478)	(0.3192)	(0.6044)	(1.4571)
Price alcohol (log)	0.6924*	-2.8245***	1.2854	-0.8486**	-3.0526***	-0.9157
	(0.3585)	(0.7131)	(2.2815)	(0.3696)	(0.6999)	(2.1799)
Observations	35,600	37,605	17,810	398,016	446,681	213,022
N. individuals	6,028	5,190	4,002	6,028	5,190	4,002
Log-likelihood	-7,743.09	-3,426.81	-722.44	-13,436.22	-5,478.30	-1,034.31

Notes: this table presents the baseline results of the discrete-time complementary log-log (cloglog) duration models with sampling weights. All specifications include a cubic polynomial function to approximate the baseline hazard function, as well as five-year intervals dummies to account for differences in the calendar years individuals were first-exposed to the risk of smoking initiation, as suggested by Korn, Graubard, and Midthune (1997). The first three columns report estimates when the event story dataset is set on a yearly frequency. The remaining columns report coefficients in which the event story data were expanded to account for a monthly frequency. Robust standard errors are reported in parentheses and clustered at the individual level. Source: ENSANUT 2012 administered by the Ecuadorian National Statistical Agency (INEC). * p.value < 0.1, ** p.value < 0.05, *** p.value < 0.01.

Table A7: Discrete-Time Complementary Log-Log Duration Models of Smoking Initiation: Heterogeneity Effects Analyses

	(1)	(2)	(3)	(4)	(5)	(6)
Price tobacco (log)	-0.6963***	-1.1008***	-0.7018***	-0.6744***	-0.8685***	-0.6985**
	(0.2571)	(0.2803)	(0.2694)	(0.2577)	(0.2926)	(0.2713)
Price alcohol (log)	-0.2885	-0.2022	-0.3505	-0.3027	-0.0825	-0.4647
	(0.2958)	(0.3858)	(0.3198)	(0.2972)	(0.3565)	(0.3257)
Female		-1.4797***				
		(0.1293)				
Female×price tobacco (log)		0.2686				
		(0.3652)				
Female×price alcohol (log)		-0.4244				
		(0.5371)				
Indigenous			-0.3351			
			(0.2183)			
Afroecuatorian			-0.2227			
			(0.3284)			
Montubio			0.4394			
			(0.3208)			
Indigenous×price tobacco (log)			-0.1567			
			(0.6057)			
Afroecuatorian×price tobacco (log)			0.2732			
			(0.9135)			
Montubio×price tobacco (log)			0.4415			
			(1.1212)			
Indigenous×price alcohol (log)			0.3218			
			(0.9092)			
Afroecuatorian×price alcohol (log)			-0.1351			
			(1.2957)			
Montubio×price alcohol (log)			1.0585			
			(1.4434)			
Former migrant				-0.4163		
				(0.6800)		
Former migrant×price tobacco (log)				-2.3278		
				(1.6596)		
Former migrant×price alcohol (log)				1.3301		
				(2.5102)		
Rural					-0.3434**	
					(0.1362)	
Rural×price tobacco (log)					0.4910	
					(0.3766)	
Rural×price alcohol (log)					-0.5924	
					(0.5590)	
Tobacco producing canton						0.3739**
						(0.1605)
Tobacco producing canton×price tobacco (log)						0.0323
						(0.4777)
Tobacco producing canton×price alcohol (log)						0.9603
						(0.6651)
Observations	95,607	95,607	95,607	95,607	95,607	95,607
N. individuals	15,968	15,968	15,968	15,968	15,968	15,968
Log-likelihood	-12,983.64	-13,003.23	-12,982.45	-12,982.38	-12,982.91	-12,981.63

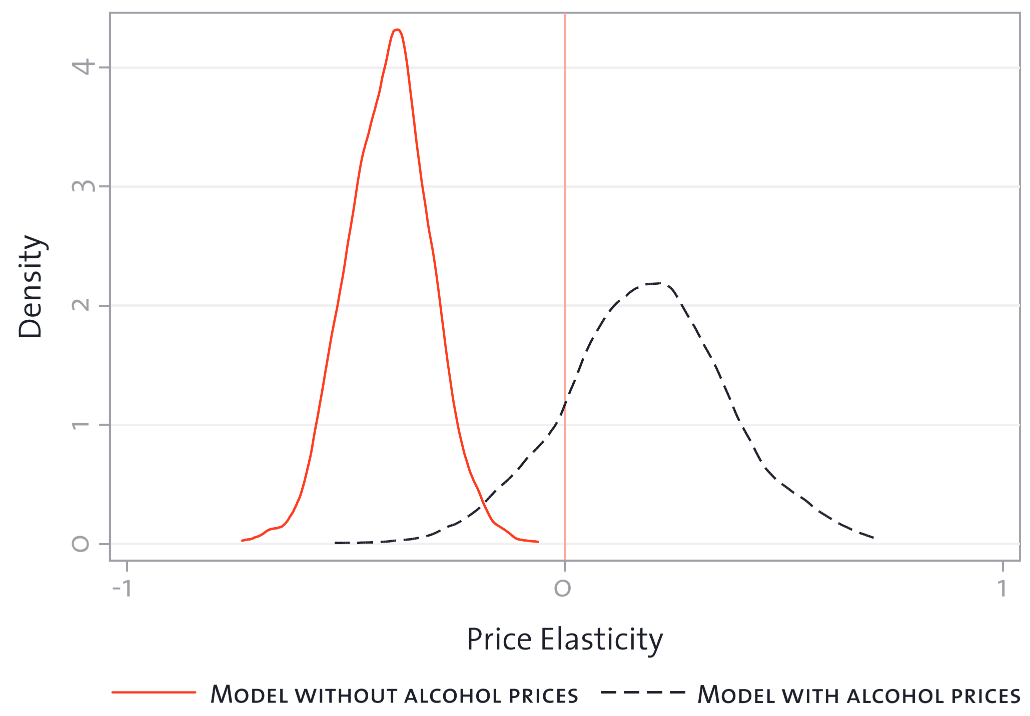
Notes: this table presents the baseline results of the discrete-time complementary log-log (cloglog) duration models with sampling weights. All specifications include a cubic polynomial function to approximate the baseline hazard function, as well as five-year intervals dummies to account for differences in the calendar years individuals were first-exposed to the risk of smoking initiation, as suggested by Korn, Graubard, and Midthune (1997). The first three columns report estimates when the event story dataset is set on a yearly frequency. The remaining columns report coefficients in which the event story data were expanded to account for a monthly frequency. Robust standard errors are reported in parentheses and clustered at the individual level. Source: ENSANUT 2012 administered by the Ecuadorian National Statistical Agency (INEC). * p.value < 0.1, ** p.value < 0.05, *** p.value < 0.01.

Table A8: Discrete-Time Complementary Log-Log Duration Models of Smoking Initiation: Simulation Tests

NCLUDING ALCOHOL PRICES	NO (1)	YES (2)
Mean	-0.402	0.184
S.E.	0.095	0.186
Min	-0.737	-0.526
25th Percentile	-0.466	0.068
50th Percentile	-0.398	0.189
75th Percentile	-0.340	0.305
Max	-0.062	0.713
N replications	1,000	1,000

Notes: This table presents descriptive statistics of sampling distributions of the simulation exercise in which the discrete-time duration model under a yearly frequency was estimated by drawing a random month per year-at-risk from a uniform distribution. Source: ENSANUT 2012 administered by the Ecuadorian National Statistical Agency (INEC).

Figure A1: Robustness Checks: Randomizing the Month of Smoking Initiation



Notes: This figure displays the sampling distribution of the price elasticity of tobacco on the smoking onset hazard, conditional on not including alcohol prices (continuous line) and including alcohol prices (dashed line) as an additional independent variable. These distributions correspond to 1,000 replications in which the month of smoking initiation was randomly drawn from a uniform distribution. Source: ENSANUT Survey 2012, administered by the Ecuadorian National Statistical Agency (INEC).

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