

Supplementary File for Cigarette prices and smoking among adults in eight sub-Saharan African countries: Evidence from the Global Adult Tobacco Survey by Samantha Filby

Appendix 1. Independent variable construction

Three types of independent variables are employed in the regressions analysis: individual-level variables, primary sampling unit (PSU)-level variables and country-level variables. Below is a list each of the independent variables used in the analysis, and a description of how that variable was derived or constructed.

Individual-level variables

All individual-level variables are derived from GATS.

Age. GATS asks the age of all individuals who are surveyed. This is a continuous variable.

Gender. GATS asks all individuals to identify their gender. This is modelled as a binary indicator equal to one if the respondent is male and zero if the respondent is female.

Residence type. This is a binary indicator equal to one if the respondent lives in an urban area, and zero if they live in a rural area.

Education. GATS asks individuals to list the highest level of education that they have completed. The education systems differ across countries, which resulted in different education levels being reported across the different surveys. I therefore created a relative measure of educational attainment in line with the approach adopted by Nargis *et al.* [1]. The relative

education categories included in the analysis are “No formal education,” “Primary schooling completed,” “Secondary schooling completed,” “Any form of tertiary education.”

Personal wealth. GATS does not collect data on personal or household income. Instead, respondents are asked about their possession of different household items. Multiple correspondence analysis is used to construct a wealth index based on each respondent’s built environment and ownership of private assets within a household. Items included in the index are access to electricity and a flush toilet in the house, and whether anyone in the household has a fixed-line telephone, a mobile phone, television, radio, refrigerator, car, scooter or a washing machine. Ownership of a computer, a bicycle or clock watch was not included across all country surveys. These items are therefore excluded from the wealth index. The index itself is divided into five quintiles, with Quintile 1 being the poorest wealth category and Quintile 5 being the wealthiest category.

The allocation of a wealth quintile to a particular individual can be based on their wealth status in relation to others in their country, or in relation to all individuals from all eight countries. I chose to assess each individual’s wealth status in the context of the pooled cross section of data. This approach to classifying an individuals’ wealth status is more appropriate because it allows one to account for the fact that standards of living may vary greatly between countries. This ensures that each wealth quintile contains those individuals who are most similar in terms of wealth, despite their geography. It also avoids allocating people from different countries to the same wealth quintile despite that these people may live in countries that have vastly different incomes.

For example, consider two countries, Mali and Norway. Mali has a GDP per capita of around 859 USD. Norway has a GDP per capita of around 67 295 USD. Being in the top income quintile in Mali and being in the top income quintile in Norway will clearly be two very different experiences. If one grouped the people in the top income quintile in Mali together with the people in top income quintile in Norway, one would be trying to liken people of vastly different incomes. By assigning people to a wealth category in a manner that accounts for the fact that standards of living may greatly between countries, one is able to compare people who are more similar in terms of their wealth status.

Employment status. In GATS, survey respondents are asked to identify any one of the following as their main work status over the past 12 months: government employee; non-government employee; self-employed; student; homemaker; retired; unemployed but able to work; and unemployed but unable to work. These options were then grouped into three categories: (1) “Employed” (includes government employees, non-government employees, and those who are self-employed), (2) “Unemployed” (includes those who are unemployed, but able to work), (3) “Not in the workforce” (includes students, homemakers, those who are retired and those who are unemployed and unable to work).

Marital status. GATS asks individuals their the marital status. Respondents can identify as single, married/cohabiting, separated, divorced, or widowed. These options were then classified into three categories: (1) “Single/never married”; (2) “Married/cohabiting” and (3) “Divorced/Separated/Widowed”.

Misinformation about harms of tobacco smoking. GATS asks all respondents: “Based on what you know or believe, does smoking tobacco cause serious illness?” We construct a binary

indicator equal to one if the respondent answered “No” or “Don’t Know” to the question, indicating that the respondent does not believe/does not know that smoking tobacco causes illness. We set the indicator equal to zero if the respondent answered “Yes” to the question, indicating that they are informed about the health harms of tobacco use.

Smoking duration. GATS asks all surveyed individuals their age, and asks all daily current cigarette smokers how old they were when they first started smoking tobacco daily. For each daily smoker, I subtract the age they started smoking daily from their age to get the number of years the individual has been a daily smoker. This regressor is only included in the second part of the two-part model, which estimates conditional demand for cigarettes. GATS does not ask non-daily smokers when they first started smoking tobacco. Non-daily smokers are thus excluded from the analysis of conditional cigarette demand.

Primary sampling unit (PSU)-level variables

All PSU-level variables are derived from GATS. These variables are constructed by aggregating and/or averaging individual responses at the PSU-level to reduce potential endogeneity of individual responses.

Cigarette prices. GATS asks daily smokers and less than daily smokers the exact number of cigarettes they purchased the last time they purchased manufactured cigarettes. GATS also asks the amount of money they spent for this purchase. These two questions are used to calculate the average purchase price for one manufactured cigarette (i.e. the amount of money spent divided by the number of cigarettes purchased). The price per stick is then multiplied by 20 to get the price per pack of 20 cigarettes in local currency.

The price per pack is then averaged at the PSU-level. Some PSUs do not contain individual responses on cigarette prices, which prevents the calculation of an average price specific to these PSUs. Following Kostova *et al.* (2013) [2], individuals in these PSUs are matched using their residence location (urban or rural) with prices averaged at the urban/rural level for each country. Cigarette prices are then transformed into a common dollar currency using country-specific purchasing power parity (PPP) conversion factors obtained from the World Bank Development Indicators [3]. This adjustment accounts for the cost of living and increases the comparability of prices across countries. Prices expressed in real 2019 PPP dollars are presented in Table 3. Prices enter the regressions in logarithmic form.

Local prevalence of cigarette advertising exposure is calculated as the PSU-level mean of a binary individual-level variable indicating whether the respondent had recently (in the last 30 days) seen any advertisements or signs promoting cigarettes through any of the following channels: television, radio, billboards, posters, newspapers, magazines, cinema, the internet, public transportation vehicles or stations, public walls. The average prevalence of cigarette advertising in our sample is 0.21, indicating that approximately 21% of respondents had been exposed to cigarette advertising.

Local prevalence of anti-tobacco media messages is calculated as the PSU-level mean of a binary individual-level indicator showing whether, in the past month, the respondent had seen any information about the dangers of using cigarettes, or any information that encourages quitting in newspapers, magazines, television, radio, or billboards.

Country-level variables

Poverty headcount ratio at PPP\$1.90 a day. These data were obtained from the World Bank Development Indicators [3].

“POWE” Composite Score. In 2008, the World Health Organization introduced a measure to assess countries’ implementation of the key demand-reduction measures recommended by the Framework Convention on Tobacco Control [4]. This measure is called the MPOWER score. The MPOWER score assigns points to countries in each of the following areas : "**M**onitor tobacco use”; “**P**rotect people from tobacco smoke”; “**O**ffer help to quit tobacco use”; “**W**arn about the dangers of tobacco”; “**E**nforce bans on tobacco advertising, promotion and sponsorship”; and **R**aise taxes on tobacco products”.

For the “M” policy dimension, the score values range from 1 to 4 in which a score of 1 represents “no known data or no recent data or data that are not both recent and representative”, and a score of 2–4 represents the weakest to the strongest level of the policy [5]. For the other five policy elements (POWER), the score measures its overall strength on a scale of 1 to 5 in which a score of 1 represents “Data not reported” and a score of 2–5 represents the weakest to strongest level of implementation of these policies [5].

An MPOWER composite score is calculated by adding up the different score in each individual component of MPOWER. Importantly, for the “W” component of MPOWER, a country is scored twice: first on a scale of 1-5 for the health warnings of cigarette packages, and second on a scale of 1-5 for the mass media anti-tobacco campaigns. In both cases, a score of 1 represents “Data not reported” and a score of 2–5 represents the weakest to strongest level of implementation of these policies.

This means that a country can earn a maximum of 34 points. The scores range from 7 (1 in each of the seven MPOWER components: recall the W component is scored twice) and 34 (4 in M component and 5 in six POWER components: recall the W component is scored twice).

For the purpose of this paper, I exclude the “M” and “R ”components of the MPOWER composite scores to obtain the “POWE” score for each country in the sample. This is because the “M” component measures the extent to which countries “monitor tobacco use and prevention policies”. This does not reflect the state of tobacco-control policy implementation in a given country. I therefore exclude it from the construction of the composite score. The “R” component of the MPOWER package is excluded because the regressions already control for cigarette prices.

To calculate the “POWE” composite score for each country, I sum the different scores for each of the individual components of “POWE”, bearing in mind that the “W” component is scored twice. This means that a country can earn a maximum of 25 points. The scores range from (1 in each of the five POWE components) and 25 (a score of five in each of the POWE components).

Appendix 2. Sensitivity analysis

This Appendix shows the results of re-running the regressions and replacing the local prevalence of cigarette advertising exposure and the local prevalence of anti-tobacco media messaging with the “POWE” composite scores for each country. The results of this exercise are presented in the two tables below. Supplementary Table S1 below compares the results of the original regression specification for smoking participation (left-hand column) with the results obtained by including the POWE composite score (the grey-shaded column).

Supplementary Table S1: Models of smoking participation under different specifications

	PART 1	PART 1
	Smoking participation (Logit: Smoking = 1)	Smoking participation (Logit: Smoking = 1)
	N= 51,122	N= 51,122
Ln(Cigarette price)	-0.014*** (0.004)	-0.015*** (0.003)
POWE Composite Score	-	-0.023 (0.031)
Local rate of exposure to cigarette advertising	0.013 (0.015)	-
Local rate of exposure to antismoking messages	0.009 (0.017)	-
Age	0.007*** (0.001)	0.007*** (0.001)
Age squared	-0.00007*** (0.000)	-0.00007*** (0.000)
Male	0.127*** (0.012)	0.126*** (0.012)
Urban	0.001 (0.008)	0.001 (0.009)
Education (base = no formal education)		
Primary schooling completed	0.007 (0.004)	0.008** (0.004)
Secondary schooling completed	0.002 (0.006)	0.002 (0.006)
Any form of tertiary education	-0.012** (0.005)	-0.011** (0.005)

Wealth (Base = lowest wealth quintile)		
Low	-0.006 (0.004)	-0.005 (0.004)
Mid	-0.011 (0.008)	-0.011 (0.008)
High	-0.020 (0.013)	-0.020 (0.013)
Highest	-0.025* (0.014)	-0.025* (0.014)
Employment (Base = employed)		
Unemployed	0.008 (0.006)	0.007 (0.006)
Not in the workforce	-0.026*** (0.0058)	-0.027*** (0.006)
Marital status (Base = single/never married)		
Married/cohabiting	-0.022*** (0.007)	-0.023*** (0.008)
Divorced/Separated/Widowed	0.016*** (0.005)	0.015*** (0.006)
Misinformed about the harms of tobacco smoking		
	0.027*** (0.009)	0.025*** (0.001)
% of the population living below the PPP\$ 1.90 poverty line		
	-0.001*** (0.000)	-0.001*** (0.000)
Price elasticity		
	-0.362***	-0.378***

Standard errors are clustered by country and indicated in parentheses.

* $p < .1$; ** $p < .05$; *** $p < .01$.

The results of the sensitivity analysis for conditional cigarette demand are presented in Supplementary Table S2. The regression specification with the POWE composite scores is in the grey highlighted column, while the results of the original specification (which includes local rates of exposure to cigarette advertising and antismoking messages instead of the POWE composite scores) are in the unhighlighted column on the left.

Supplementary Table S2: Models of conditional cigarette demand under different specifications

	PART 2	PART 2
	Conditional demand	Conditional demand
	(Dep. var. = ln(consumption))	(Dep. var. = ln(consumption))

	N= 2,284	N= 2,284
Ln(Cigarette price)	-0.133*** (0.031)	-0.128*** (0.040)
Smoking duration	0.003 (0.002)	0.003 (0.002)
Ln(Cigarette price) x Smoking duration	0.004** (0.001)	0.003** (0.001)
POWE Composite Score	-	-0.024 (0.023)
Local rate of exposure to cigarette advertising	0.028 (0.067)	-
Local rate of exposure to antismoking messages	-0.166 (0.120)	-
Age	0.007 (0.005)	0.006 (0.005)
Age squared	-0.0002** (0.000)	-0.0002** (0.000)
Male	0.149*** (0.041)	0.150*** (0.038)
Urban	0.035 (0.035)	0.036 (0.035)
Education (base = no formal education)		
Primary schooling completed	0.016 (0.030)	0.005 (0.025)
Secondary schooling completed	0.022 (0.040)	-0.002 (0.038)
Any form of tertiary education	0.036 (0.047)	0.035 (0.046)
Wealth (Base = lowest wealth quintile)		
Low	0.116* (0.061)	0.111* (0.067)
Mid	0.158** (0.078)	0.015** (0.071)
High	0.162** (0.080)	0.149** (0.072)
Highest	0.134* (0.071)	0.113* (0.064)
Employment (Base = employed)		
Unemployed	0.084* (0.045)	0.071 (0.045)

Not in the workforce	-0.020 (0.039)	-0.012 (0.043)
Marital status (Base = single/never married)		
Married/cohabiting	0.033 (0.033)	0.049 (0.032)
Divorced/Separated/Widowed	0.000 (0.043)	0.014 (0.034)
Misinformed about the harms of tobacco smoking	0.023 (0.0706)	0.019 (0.069)
% living below the poverty line	-0.004** (0.002)	-0.004** (0.002)
Price elasticity	-0.133***!	-0.128***!

Standard errors are clustered by country and indicated in parentheses.

* $p < .1$; ** $p < .05$; *** $p < .01$.

! indicates that this is the price elasticity of demand for people who have just started smoking. As indicated by the coefficient on the interaction between cigarette price and smoking duration, the price elasticity of demand becomes less elastic as smoking duration increases.

List of references

- [1] Nargis N, Yong H-H, Driezen P, *et al.* Socioeconomic patterns of smoking cessation behavior in low and middle-income countries: Emerging evidence from the Global Adult Tobacco Surveys and International Tobacco Control Surveys. *PLoS One* 2019;14(9):e0220223-e0220223.

- [2] Kostova D, Tesche J, Perucic AM, *et al.* Exploring the relationship between cigarette prices and smoking among adults: a cross-country study of low- and middle-income nations. *Nicotine Tob Res* 2014;**16 Suppl 1**:S10-15.
- [3] World Bank. World Bank Development Indicators. 2019.
- [4] Hiilamo H, Glantz S. Global Implementation of Tobacco Demand Reduction Measures Specified in Framework Convention on Tobacco Control. *Nicotine & Tobacco Research* 2021;**24**(4):503-510.
- [5] World Health Organization. WHO report on the global tobacco epidemic 2021: addressing new and emerging products. 2021.