Drug and Alcohol Dependence Reports 5 (2022) 100102

Contents lists available at ScienceDirect

Drug and Alcohol Dependence Reports

journal homepage: www.elsevier.com/locate/dadr

Effect of cigarette prices on cigarette consumption in Ghana

Micheal Kofi Boachie[a,e,*], Rebecca Nana Yaa Ayifah[b,g], Mustapha Immurana[c], John Kwaku Agyemang[d,f], Arti Singh[d], Hana Ross[e]

[a] SAMRC/Wits Centre for Health Economics and Decision Science – PRICELESS SA, Faculty of Health Sciences, Wits School of Public Health, University of the Witwatersrand, Parktown, Johannesburg, 2193, South Africa
[b] Department of Economics, University of Ghana, Legon, Ghana
[c] Institute of Health Research, University of Health and Allied Sciences, PMB 31, Ho, Ghana
[d] School of Public Health, KNUST, Kumasi, Ghana
[e] Research Unit on the Economics of Excisable Products (REEP), School of Economics, University of Cape Town, Cape Town 7700, South Africa
[f] Internal Audit Department, KNUST, Kumasi, Ghana
[g] Centre for Economic and Social Research, African Institute for Development Research and Evaluation, Accra, Ghana

ARTICLE INFO

Keywords:
Cigarette consumption
Taxation
Price
Ghana
Elasticity

ABSTRACT

Introduction: Noncommunicable diseases are on the rise globally, with tobacco consumption being a major risk factor. Reducing tobacco consumption is an important step towards reducing the incidence and prevalence of many noncommunicable diseases. Tax and price measures have been proposed as tobacco control tools. This study investigated the link between cigarette prices and cigarette consumption in Ghana.

Methods: Annual time series data for the period 1980–2016 were used. The data came from diverse sources, including WHO, World Bank, and tobacco industry documents. Dynamic Ordinary Least Squares (DOLS), cointegration techniques, and three-stage least squares (3SLS) were used to analyze the data.

Results: After controlling for education, income, and population growth, we estimated that the price elasticity of cigarette demand is between -0.35 and -0.52 and statistically significant at 1% level. In the short run, the price elasticity is -0.1. Another variable that significantly reduced cigarette consumption during the period was education, with an elasticity between -1.7 and -2.7.

Conclusion: Cigarette demand in Ghana is influenced by cigarette prices and education. We conclude that tobacco taxes that significantly raise retail prices of cigarettes and higher education (including health education) will help reduce cigarette consumption.

1. Introduction

Tobacco is one of the most researched excisable goods (IARC, 2011). This may be due to the fact that tobacco consumption is a major cause of morbidity and mortality worldwide (World Health Organization, 2019a), and it places a substantial economic burden on countries (Goodchild et al., 2018; Boachie et al., 2021b). Consequently, governments use special taxes (i.e., excise tax) as one of the measures to discourage tobacco consumption while generating revenue (Van Walbeek, 2010; Chaloupka et al., 2012a).

Knowledge about the demand for excisable products such as cigarettes and other types of tobacco is important for public policy, especially regarding health. Indeed, evidence from both developed and developing countries shows that people respond to price changes and that raising the retail price of tobacco products, through increases in taxes, negatively affects consumption (Bader et al., 2011; Farrelly et al., 2012; Chaloupka et al., 2012b; Chelwa and van Walbeek, 2019; Dare et al., 2021) and also prevalence rates (Immurana et al., 2021). Although some studies find no evidence that tobacco taxation prevents initiation, or encourages cessation among young people (Liu, 2010), substantial evidence suggests that higher retail prices (resulting from increased taxes) are effective as it encourages cessation by people with tobacco use disorder (Dauchy and Ross, 2019), especially at older ages (Liu, 2010); prevents initiation by potential consumers (Vellios and Van Walbeek, 2016; Dauchy and Ross, 2019; Asare et al., 2019; Boachie et al., 2022b) and reduces the number of relapses (Liu, 2010; IARC, 2011). Those who are unable to quit tobacco use completely also reduce their daily consumption (Boachie and Ross, 2020).

The degree to which consumption responds to price changes differs by country and region. On average, a 10% increase in cigarette

* Corresponding author.
E-mail address: mkboachie@gmail.com (M.K. Boachie).

https://doi.org/10.1016/j.dadr.2022.100102
Received 16 December 2021; Received in revised form 31 August 2022; Accepted 15 September 2022

prices is associated with about 2–5% reduction in tobacco consumption in high-income countries and 4–8% reduction in low- and middle-income countries (IARC, 2011; NCI/WHO, 2016). Price elasticity of demand estimates for cigarettes and other tobacco products exist for a few African countries (Boshoff, 2008; Vellios and Van Walbeek, 2016; Ho et al., 2017; Chelwa and van Walbeek, 2019; Asare et al., 2019; Dauchy and Ross, 2019; Boachie and Ross, 2020; Boachie et al., 2022a). These studies have confirmed that higher cigarette prices reduce cigarette consumption, through reduced smoking participation and intensity. In Africa, low-income countries have the highest price elasticity (-0.562), with middle–high-income countries having -0.489. Lower–middle-income countries have the lowest price elasticity, -0.486 (Ho et al., 2017). This suggests that tobacco taxation is an important tool for the reduction of cancers and many other smoking-related non-communicable diseases.

Although few people consume tobacco in Ghana, it is estimated that Ghana will have 1.2 million consumers by 2025 (World Health Organization, 2015). Tobacco products consumed in Ghana include cigarettes, cigars, cheroots, and cigarillos, with cigarettes accounting for 90% of all tobacco consumption (Boachie et al., 2021a). Traditional smokeless tobacco locally known as “tawa” is also consumed. This makes cigarettes the most consumed tobacco product in Ghana. Adult smoking prevalence has declined over the last few years from 8% in 2011 to 2.8% in 2017. The declining trend is similar for both sexes: the proportion of male and female adults that smoked decreased from 10% to 5.4% and 3% to 0.1% in 2011 and 2017, respectively (World Health Organization, 2019b). Statistics from the 2017 Global Youth Tobacco Survey (GYTS) show that about 9% of students aged 13-15 years use tobacco products with 2.8% (3.2% of males and 2.3% of females) smoking cigarettes (CDC et al., 2018). However, tobacco use may become more prevalent among females in the future given that the difference between the prevalence rates for male and female youth is smaller than that of adults. According to Boachie et al. (2022a), the high prevalence of future tobacco use in many African countries will be driven by initiation among the youth due to industry tactics that seek to target young people. The projected relatively high smoking rate, (including the use of shisha and e-cigarettes), in Ghana is troubling since more than 5000 people currently die from tobacco-related diseases annually (World Health Organization, 2015). The total economic cost associated with tobacco use in Ghana is estimated at US$ Purchasing Power Parity 123 million (Goodchild et al., 2018).

Ghana ratified the World Health Organization Framework Conversion on Tobacco Control (WHO FCTC) in November 2004. However, before 2012, there was no comprehensive legislative instrument that regulated tobacco consumption or its sale in Ghana. The Public Health Act (Act 851) of 2012 prohibits smoking in public places and the sale of tobacco products in health and educational facilities (Gov’t. of Ghana, 2012). A legislative instrument 2247 (LI) to provide extra legal backing to tobacco control was passed in 2016. The LI prescribed some non-price measures such as display of no smoking signs and depiction of tobacco in entertainment media, no sale to minors, and registration of tobacco products, persons, or entities trading in tobacco. These laws and policies coupled with taxation may have contributed to the lower prevalence of tobacco use in Ghana (Gov’t. of Ghana, 2016).

While a combination of policies including increases in excise taxes, comprehensive bans on tobacco marketing and smoking in public places as well as providing treatments for people with tobacco use disorder contribute to cessation and prevention, the most cost-effective tool is the one that significantly increases the retail price of tobacco products (IARC, 2011; NCI/WHO, 2016) since it requires relatively less pecuniary resources and time to implement. Increasing excise taxes on tobacco products has been found to be the single most effective way to reduce tobacco consumption and by implication tobacco-related mortality and morbidity (IARC, 2011; NCI/WHO, 2016).

As of 2019, Ghana uses an ad valorem tax structure for tobacco products and the base for determining the tax payable is the Cost, Insurance, and Freight (CIF). The excise tax rate has been 175% since 2016 compared to 140% in 2007 which affects the retail price of tobacco products although the effect on prices will depend on the extent of tax pass-through. But how does retail price affect aggregate cigarette consumption? To answer this question, this paper estimated the price elasticity of demand for cigarettes in Ghana using cointegration analysis and annual time series data for the period 1980–2016.

Although previous studies have analyzed the determinants of smoking (participation and/or intensity) in Ghana (Nketiah-Amponsah et al., 2018; Asare et al., 2019; Boachie et al., 2022b), it is only Asare et al. (2019) and Boachie et al. (2022b) who, respectively, estimate the effect of retail prices and relative income price (RIP) on smoking participation. Previous studies have focused on specific sections of the population. For instance, Asare et al. (2019) and Boachie et al. (2022b) conducted their analysis on youth and adolescents, while Nketiah-Amponsah et al., 2018 focused on adult men in Ghana without considering the effect of price. These studies provide limited information on how the aggregate quantity of cigarettes consumed responds to price changes since the studies use individual-level data. The present study differs from previous studies on Ghana since it uses aggregate cigarette consumption data for all consumers of cigarettes for a significant number of years. By this, we contribute to the literature on the impact of economic variables such as cigarette prices and income on consumption by accounting for the effects of factors such as income, population, and education.

2. Methods

2.1. Data sources and variables

The study used annual time series data covering the period 1980–2016. The data were compiled from various publications of WHO, GlobalData, World Bank, Ghana Statistical Service (GSS), and the tobacco industry.[1] Apart from GlobalData, all data are publicly available in the sources provided, including definition and measurement of the variables. Data from GlobalData were purchased by the Research Unit on the Economics of Excisable Products (REEP) which is based at the University of Cape Town. GlobalData is a data analytics firm that compiles and sells data on tobacco, sugar-sweetened beverages and many other consumables. The data purchased was contained in the report titled “Cigarettes in Ghana, 2020”. This report provides information on aggregate cigarette consumption, prevalence rates, market shares of various cigarette brands and market concentration among other tobacco use indicators. Whenever there were gaps in the data, linear interpolation was implemented (using routine commands in Stata, *ipolate* and *epolate*) to obtain an estimate of the variable for those years.[2] Stata version 15 and Microsoft Excel were used to perform data analyses.

Following previous studies, we use real cigarette prices (inclusive of taxes), real per capita income, and education as independent variables in our demand equation. Cigarette consumption is measured by the number of cigarettes consumed. All variables were log-transformed to correct any skewness in the data and to obtain elasticities directly. Table 1 describes the variables used and the definitio8ns as found in data sources.

2.2. Test for unit root and cointegration

Our empirical strategy started with testing the properties of the data. To do this, we employed the Augmented Dickey Fuller (ADF), Philips and Perron (PP) and Kwiatkowsky, Philips, Schmidt, and Shin (KPSS) unit root tests. The stationarity test applies to the variables in equation 1.

[1] See appendix for full description of data sources.

[2] Interested readers may consult Stata software package (https://www.stata.com/manuals/dipolate.pdf) to learn how to perform linear interpolation.

Table 1
Summary of variables and data sources.

Variable	Data source	Years	Definition/data measurement
C	See appendix for details	1980–2016	This is annual cigarette consumption measured by the number of cigarettes consumed in the country
Y	World Bank	1980–2016	Gross domestic product per capita, measured by the value of all goods and services produced in Ghana.
Edu	World Bank	1980–2016	Edu is education, measured as primary school gross enrollment ratio which is defined by the World Bank as the ratio of total primary school enrollment, regardless of age, to the population of the age group that officially corresponds to the level of education. In Ghana, children start primary education at age 6. The primary education lasts for 6 years divided into a 3-year lower primary phase and a 3-year upper primary levels. Ghana's primary education curriculum places an emphasis on reading and writing, arithmetic and the development of problem-solving abilities among children.
Pop15	World Bank	1980–2016	Pop15 is the number of males and females aged 15 years or older) in Ghana for any given year
P		1980–2016	Real retail price of the most sold brand of cigarettes (20 pack).
Openness	World Bank	1980–2016	Trade openness, and it is measured by the sum of import and exports divided by GDP. It is usually referred to as trade-to-GDP ratio.
HHI	See appendix	1984–2016	Herfindahl–Hirschman Index is a commonly used measure of industry competition, calculated by squaring the market share of each firm competing in a market and then summing the resulting numbers.
Investment	World Bank	1980–2016	Investment, measured by gross fixed capital formation which includes land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. It is measured as share of GDP.
FDI	World Bank	1980–2016	This is the sum of the value of equity capital, reinvestment of earnings, and other capital. It is measured by net inflows of FDI as share of GDP
Ex	See appendix	1984–2016	This is the real excise tax on a 20-pack of cigarettes, measured in Ghana cedis

Notes: definitions are as provided in the data source. For variables with different sources, readers may consult the sources listed in the appendix for more details.

Non-stationarity of the series would imply cointegration (Hsiao and Fujiki, 1998).

Economic theory predicts that, all other things being equal, an increase in the price of a commodity reduces its demand, while an increase in income would lead to an increase its demand (for normal goods). This presupposes that cigarette demand is influenced by changes in variables such as the retail price and income in the long run. To study the long-run determinants of cigarette consumption in Ghana, the long-run demand equation was specified following previous studies (Ross and Al-Sadat, 2007; Etilé and Jones, 2011; Martinez et al., 2015; Tingum et al., 2020). The equation is of the form:

$$C_t = \beta_0 + \beta_1 P_t + \beta_2 Y + \beta_3 Edu_t + \beta_4 Pop15 + \varepsilon_t \quad (1)$$

where C_t is the quantity of cigarettes consumed during the period, P_t is the inflation-adjusted retail price of the most sold brand of cigarette (in Ghana cedis), Y is real per capita income in 2016 Ghana cedis, *Edu* is education (measured as primary school gross enrollment ratio which is defined by the World Bank as the ratio of total primary school enrollment, regardless of age, to the population of the age group that officially corresponds to the level of education), Pop15 is total population (measured as the number of males and females aged 15 years or older) and β_s are a vector of the parameters to be estimated, while ε_t is the error term. The variables education, real per capita income, and population were sourced from World Bank's World Development Indicators database. Data on consumption and retail prices were sourced from industry documents, WHO, GlobalData and Ghana Statistical Service (see appendix D).

To establish the existence of a long-run relationship between the dependent and the independent variables (i.e., equation 1), we used Shin (1994) residual-based cointegration test procedures. The null hypothesis is the existence of cointegration, and the test statistic is LM based. The Shin test is based on parametric correction of endogeneity and serial correlation. First, it involves estimating equation 1 using the dynamic OLS (DOLS) estimator by Stock and Watson (1993) in the first-step regression. The DOLS procedure involves regressing any I(1) variables on other I(1) variables, or regressing I(1) variables on any I(0) variables. It is performed with leads and lags of the first differences of the variables (Masih and Masih, 1996).

In the second step, the KPSS unit root test was applied to the residuals from the DOLS estimation of equation 2 to test the cointegration between the dependent variable and the independent variables; the alternative hypothesis is no cointegration. There is no stable long-run relationship between cigarette demand and the regressors if the null of cointegration is not validated. The coefficients from the DOLS estimator are the long-run effects and have been corrected for endogeneity and serial correlation.

Error correction model

To capture short-run dynamics and confirm the Shin cointegration test, equation 2 which is the error correction representation of equation 1 was estimated.

$$\Delta C_t = \beta_0 + \sum_{i=1}^{p-1} \beta_i \Delta C_{t-i} + \sum_{i=1}^{p-1} \gamma_i \Delta P_{t-i} + \sum_{i=1}^{p-1} \delta_i \Delta Y_{t-i} + \sum_{i=1}^{p-1} \theta_i \Delta Edu_{t-i} + \sum_{i=1}^{p-1} \Psi_i \Delta Pop15_{t-i} + \alpha ECT_{t-1} + \varepsilon_t \quad (2)$$

Where ECT_{t-1} is the error correction term, one period lag of the residuals from the cointegration regression in equation 2, obtained as $ECT_{t-1} = C_{t-1} - (\beta_1 P_{t-1} + \beta_2 Y_{t-1} + \beta_3 Edu_{t-1} + \beta_4 Pop15_{t-1})$. A statistically significant negative coefficient of the error correction term ECT_{t-1} will confirm the existence of long-run equilibrium relationships between cigarette demand and the independent variables. Thus, using the statistical significance of the error correction term, or using the stationarity of the cointegration regression residuals (using the KPSS unit root test) should give the same conclusion about the existence of a long-run relationship.

2.3. Robustness check

To check the sensitivity of our estimates, we conducted robustness checks. Our robustness analysis used a system of multiple equation regression framework. We specified two additional equations, one for price and the other for income to estimate cigarette demand:

$$P_t = \beta_s + \beta_1 C_t + \beta_2 Y_t + \beta_3 Ex_t + \beta_4 Openness_t + \beta_5 HHI_t + \mu_t \quad (3)$$

In equation 3, *Ex* is real tax (excise and other taxes), *openness*, trade openness (measured as the sum of exports and imports) to Gross Domestic Product (GDP), and *HHI* is Herfindahl–Hirschman Index, a commonly used measure of industry competition, and it is calculated using data on market shares of the companies. All other variables are as previously defined. The reasons for the variables in equation 3 were based on economic theory and previous empirical studies (Chaloupka et al., 2010; Appau et al., 2017). These studies have shown that trade openness increases available of cigarettes and many other products which in turn

Table 2
Shin 1994 Cointegration test.

Test	Test Statistic	Shin Cu Statistic at 1%	Remarks
KPSS	0.195	0.208	Presence of Cointegration

influences retail prices given demand conditions in domestic economies. Also, the level of industry competition influences pricing strategies of firms since each manufacturer would want to gain a significant share of the market.

$$Y_t = \beta_s + \beta_1 Investment_t + \beta_2 C_t + \beta_3 Openness_t + \beta_4 FDI_t + \beta_5 Edu_t + \eta_t \quad (4)$$

Where Y is real per capita income; Investment is measured by the ratio of gross fixed capital formation to GDP; FDI is foreign direct investment, measured by net inflows of FDI to GDP. All other variables are as previously defined.

Equations 1, 3 and 4 are estimated simultaneously using the three-stage least squares (3SLS) estimator Zellner and Theil, 1962; Gallant, 1977). Simultaneous equation estimators such as the 3SLS provide a less complex way to determine the parameters of interest. The 3SLS estimator, which is a combination of the 2SLS and Seemingly Unrelated Regressions (SURE), addresses both endogeneity issues and cross-correlations among the error terms in various equations (Zellner and Theil, 1962). The 3SLS uses information on the correlation of the stochastic disturbance terms of equations 1, 3, and 4 to provide a more asymptotically efficient estimates (Zellner and Theil, 1962; Gallant, 1977). Another advantage of the 3SLS estimator is that it is valid and consistent regardless of whether the variables under investigation are I((1) or not (Hsiao, 1997; Hsiao and Fujiki, 1998). Given that valuable information is lost when variables are differenced (Perman, 1991; Hsiao and Fujiki, 1998) and given the validity of 3SLS estimates irrespective of the integration order, we estimate equations 1, 3 and 4 in levels. Recently, the 3SLS approach was used empirically to study infant mortality and government health spending in low- and middle-income countries (Boachie et al., 2020). For information purposes, we report the results from SURE estimations. The Hausman test is used to determine the choice between SURE and the 3SLS. If price and income are exogenous, the SURE model produces asymptotically efficient and consistent estimates in the absence of simultaneity between price and consumption.

3. Results

3.1. Unit root and cointegration tests

The unit root test results are presented in Table 1. The test was conducted to ensure that none of the variables to be used in the dynamic OLS estimation were I(2). Using the ADF and PP test, two variables, i.e., log real price and log population, were stationary at levels depending on whether a deterministic trend is added to the regression or not. Overall, we concluded that none of the variables under study (eq. 1) were integrated of order two. Therefore, we proceeded to obtain the long-run coefficients using the DOLS estimator and predicted the residuals.

The Shin and bounds test for cointegration indicated the existence of long-run relationships between cigarette consumption and the independent variables. The cointegration test results are provided in Tables 2 and 3, respectively.

3.2. Long -run coefficients

The coefficients from the DOLS regression are presented in Table 4. Except for population, all variables (i.e., price, income, and education) were statistically significant at 1%, and are in line with a priori expectations. Cigarette consumption responded positively to real income and negatively to real price. The price and income elasticities were, respectively, -0.35 and 0.5, while that of education was -2.7. This implies that higher prices were associated with lower cigarette consumption, while higher income encouraged cigarette use which is in line with theoretical postulations. The negative effect of education on cigarette consumption was larger than that of price.

We tested for the robustness of the results using simultaneous equation modelling. The system of equations was estimated using SURE and 3SLS. The Hausman test rejected the exogeneity of price and income. Therefore, we used the 3SLS estimates. The coefficients of price, education, and population were statistically significant at 1%. The income elasticity was insignificant. The price elasticity of cigarette demand was -0.52, higher than the DOLS estimate. The elasticities for education and population growth were -2 and -0.87, respectively. The 3SLS and SURE estimates are presented in Table 4.

Overall, we found that the statistical significance of the long-term effects of income and population growth were sensitive to the estimator used, while that of price and education are statistically significant irrespective of the estimator.

Table 3
Bounds Test To cointegration based on ARDL (2,0,1,0,0).

Equation/Model 1	F	K	Critical values		
C = f(P, Y, Edu, Pop15)	4.683	4	%	I(0)	I (1)
			10	2.671	3.902
			5	3.243	4.635
			1	4.606	6.368

Table 4
Determinants of cigarette consumption, 1980–2016.

VARIABLES	DOLS 1980–2016	SURE 1984–2016	3SLS 1984–2016
lnY	0.500***	0.503	0.711
	(0.175)	(0.273)	(0.446)
lnprice	-0.351***	-0.250***	-0.518***
	(0.057)	(0.065)	(0.159)
lnedu	-2.671***	-1.746***	-1.990***
	(0.321)	(0.413)	(0.590)
lnpop15	0.002	-0.949***	-0.873***
	(0.087)	(0.203)	(0.272)
Constant	11.627***	24.090***	22.504***
	(1.208)	(1.577)	(2.295)
Observations	33	33	33
R-squared	0.99	0.958	0.924

Standard errors in parentheses
*** $p < 0.01$.** $p < 0.05$.

3.3. Short-run coefficients

In the short-term, price was statistically significant at 5%, whereas education and income were significant at 10% (see Table 5). The short-run price elasticity is -0.1, while that of income and education are -0.9. and -0.54, respectively.

The effect of population was statistically insignificant. The adjustment coefficient of -0.22 was statistically significant at 5% which also confirms the existence of a long-run relationship among the variables. The adjustment coefficient indicates that 22% of the deviations from the steady state are corrected in the current year towards equilibrium.

4. Discussion

Excise taxes and its ultimate impact on cigarette consumption through prices have received attention in the literature on tobacco

Table 5
Short-run coefficients, 1980-2016.

Variables	
LD.lnc	0.173
	(0.196)
LD2.lnc	0.314*
	(0.170)
D.lnprice	-0.0914**
	(0.0419)
D.lnedu	-0.542*
	(0.307)
D.lnpop15	3.671
	(5.784)
D.lnY	-0.903*
	(0.454)
ECT(-1)	-0.217**
	(0.0964)
Constant	0.174
	(0.115)
Observations	36
R-squared	0.386

Standard errors in parentheses.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

control. However, few studies exist in Ghana (Asare et al., 2019; Boachie et al., 2022b) despite many studies on tobacco control in Ghana (e.g., Owusu-Dabo et al., 2009; John et al., 2012; Doku et al., 2012; Mamudu et al., 2013). This paper contributes to the literature on the economic determinants of cigarette consumption in Ghana for the period 1980–2016 while controlling for education and population. We found that cigarette consumption during this period was significantly influenced by price, income and education. The main results show that a 10% increase in cigarette prices was associated with between 3.5% and 5.2% decline in long-term cigarette consumption. Other time series analysis showed that price elasticity of cigarette demand ranged between -0.18 and -0.72 in South Africa (Boshoff, 2008; Tingum et al., 2020), -0.57 in Malaysia (Ross and Al-Sadat, 2007), and -1.17 in Pakistan (Mushtaq et al., 2011). In Argentina, Martinez et al. (2015) and Rodríguez-Iglesias et al. (2017), respectively, found price elasticity to be -0.31 and -0.28. Ghana's price elasticity of demand for cigarettes, estimated in this study, is similar to that of high-income countries, -0.52 or less. This suggests that taxes that raise retail prices significantly can reduce cigarette consumption in Ghana. While the results are qualitatively similar to our estimates, at least in terms of sign and statistical significance of the estimates, the magnitudes differ. The reason for this is that data coverage and estimation methods used in previous studies differ from our study. Secondly, the market structures and tax structures (including rates) are differ by country. For instance, South Africa uses a specific tax structure, while Ghana uses ad valorem tax structure and each of these tax structures has differing effect on retail price. We also note that there is no study on price elasticity of aggregate cigarette demand in Ghana that we can compare our estimates with.

Other factors influencing cigarette consumption are income and education. We found the income elasticity of cigarette demand to be about 0.5, suggesting that cigarette consumption will rise by 5% if there is a 10% increase in income. This is similar to income elasticity estimates from Argentina (Martinez et al., 2015; Rodríguez-Iglesias et al., 2017). In the case of education, a 10% increase in enrollment was also associated with between 20% and 27% decline in cigarette consumption.

In the short-term, a 10% increase in cigarette prices was associated with a 1% decrease in cigarette consumption. The effect of income, education, and population were statistically insignificant at conventional levels.

Overall, the results show that higher prices and education have contributed to the decline in cigarette consumption in Ghana. This is expected given that rising prices make cigarettes more expensive *ceteris paribus*, causing some tobacco consumers to reduce the quantity of cigarettes consumed while others quit or do not initiate (IARC, 2011). The WHO FCTC Article 6 encourages parties to use tax and price measures to control tobacco use. This study has shown that cigarette demand negatively responds to price changes hence fully implementing the FCTC Article 6 in Ghana will reduce cigarette consumption.

Education also affects the probability of initiating smoking and cessation (Fernandez et al., 2001; Owusu-Dabo et al., 2009; Etilé and Jones, 2011; Vellios and Van Walbeek, 2016). This suggests that coupled with price, education encouraged many tobacco consumers to quit, while others did not initiate which contributed to the reduced consumption during the period.

5. Conclusion

This study investigated the determinants of cigarette consumption in Ghana, with a particular focus on the role of cigarette prices. Using Stock and Watson's dynamic OLS estimator and 1980–2016 data, we found that a 10% increase in real cigarette prices reduced cigarette consumption by between 3.5% and 5.2% in the long term, and 1% in the short term. Other factors influencing cigarette consumption were education and income. The findings support the economic theory that people respond to price changes. Thus, continuous increase in tobacco taxes along with higher education would contribute to the reduction in cigarette consumption.

Funding

Financial support comes from the International Development Research Centre (Grant Number: 108820-001), with additional support from the SAMRC/Wits Centre for Health Economics and Decision Science – PRICELESS SA (South African Medical Research Council Grant Number: 23108).

Role of funding source

The funders had no role in the design, analysis, or interpretation, preparation of the study.

Declaration of competing interest

The authors declare that they have no conflict of interest.

CRediT authorship contribution statement

Micheal Kofi Boachie: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Software, Writing – original draft, Writing – review & editing, Funding acquisition. **Rebecca Nana Yaa Ayifah:** Data curation, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Mustapha Immurana:** Investigation, Methodology, Writing – review & editing. **John Kwaku Agyemang:** Writing – review & editing. **Arti Singh:** Writing – review & editing. **Hana Ross:** Investigation, Methodology, Funding acquisition, Writing – review & editing.

Appendix

Table A1
A. Unit Root Test Results
The null hypothesis is the presence of cointegration against the alternative of no cointegration.

Table A1
Unit root test results (1980-2016).

Panel A	Constant					
	ADF		PP		KPSS	
Variable	Level	1st Difference	Levels	1st Difference	Levels	1st Difference
Lnc	-1.142	-4.257***	-1.102	4.039***	1.85	0.1***
Lnprice	-3.024**	-5.865***	-3.280**	-7.801***	0.471***	0.061***
LnY	1.671	-3.026**	0.802	-2.898**	1.65	0.573**
Lnedu	-0.275	-7.042***	-0.252	-6.975***	1.67	0.14***
Lnpop15	-5.670***	-2.275	-4.118***	-2.826**	1.92	0.625***
Panel B	Constant and trend					
	ADF		PP		KPSS	
Variable	Level	1st Difference	Levels	1st Difference	Levels	1st Difference
lnc	-1.609	-4.109***	-2.129	-4.033***	0.159***	0.089***
lnprice	-3.750**	7.273***	-3.697**	-7.749***	0.112***	0.024***
lnY	-3.230*	3.409**	-2.997	-3.491**	0.657	0.139***
lnedu	-2.140	-7.065***	-2.163	-7.007***	0.487	0.049***
lnpop15	-0.249	-4.890***	-0.577	-4.364**	0.715	0.116***

*** Rejection of the null hypothesis of the presence of unit rootB. Results from Cointegration Test

Appendix D

Notes on Data sources

1. Tax and Price for 2008, 2010, 2014, and 2016 are from WHO report on the global tobacco epidemic 2017, Appendix IX, Table 9.1)
2. Tax and Price for 2009 is from Ghana FCTC Report Card 2009; https://www.afro.who.int/sites/default/files/2017-09/Ghana_report_card_0.pdf
3. Tax and Price for 1980–1996 are from World summary of cigarette retail prices, tax burdens and tax incidence.: Philips Moris Records 1996 [Available from: https://www.industrydocuments.ucsf.edu/docs/}id=glhf0066
4. Tax and Price for 2000 com from WHO factsheet on tobacco (available at: https://www.who.int/tobacco/media/en/Ghana.pdf (accessed: 28 January 2019).
5. Consumption data for 1984–1989 come from The Maxwell Consumer Report, 25 March 1992. Source: http://industrydocuments.library.ucsf.edu/tobacco/docs/mmpn0145. Note that data for 1980–1983 are interpolated.
6. Consumption data for 1990–2016 come from Cigarettes in Ghana, 2020. GlobalData Report Number CG0709MR, 2020.
7. Consumer Price Index (tobacco specific) from Ghana Statistical Service. Consumer Price Index (Time Series), Updated 15 August 2012. https://statsghana.gov.gh/gssmain/fileUpload/National%20Accounts/TimeSeries_CPI_2012-08-15.pdf
8. Tax and Price for 1998, 1999, 2001–2007, 2011, 2013, and 2015 are interpolated.
9. Data on Trade openness, per capita income, education, foreign direct investment, gross fixed capital formation for the period 1980–2016 come from World Bank. World Development Indicators: World Bank; 2022 [Available from: https://databank.worldbank.org/source/world-development-indicators.
10. Education data for 1998 and 2010 are interpolated.
11. Consumption data for 1984–1989 come from Wilson, MJ. (1975). Tobacco consumption in various countries. Research Paper 6, 4th Edition. Tobacco Research Council. http://industrydocuments.library.ucsf.edu/tobacco/docs/ntdc0211
12. Market shares data for 1998 and 1999 come from 2000 Maxwell Tobacco Factbook, http://industrydocuments.library.ucsf.edu/tobacco/docs/nshf0189
13. Market shares sourced from Global Data; Data for 2000-2016, Global Data Report on Ghana Cigarettes Report Number CG0709MR, 2020
14. Market share data for 1992–1997 come from Marketing: http://industrydocuments.library.ucsf.edu/tobacco/docs/lqgf0205 and http://industrydocuments.library.ucsf.edu/tobacco/docs/qlmj0212
15. Market share data for 1984–1991 come from Maxwell consumer report, 25 March 1992. Source: http://industrydocuments.library.ucsf.edu/tobacco/docs/mmpn0145

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