An empirical analysis of cigarette demand in Argentina

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ABSTRACT

Objective To estimate the long-term and short-term effects on cigarette demand in Argentina based on changes in cigarette price and income per person >14 years old.

Method Public data from the Ministry of Economics and Production were analysed based on monthly time series data between 1994 and 2010. The econometric analysis used cigarette consumption per person >14 years of age as the dependent variable and the real income per person >14 years old and the real average price of cigarettes as independent variables. Empirical analyses were done to verify the order of integration of the variables, to test for cointegration to capture the long-term effects and to capture the short-term dynamics of the variables.

Results The demand for cigarettes in Argentina was affected by changes in real income and the real average price of cigarettes. The long-term income elasticity was equal to 0.43, while the own-price elasticity was equal to −0.31, indicating a 10% increase in the growth of real income led to an increase in cigarette consumption of 4.3% and a 10% increase in the price produced a fall of 3.1% in cigarette consumption. The vector error correction model estimated that the short-term income elasticity was 0.25 and the short-term own-price elasticity of cigarette demand was −0.15. A simulation exercise showed that increasing the price of cigarettes by 110% would maximise revenues and result in a potentially large decrease in total cigarette consumption.

Conclusion Econometric analyses of cigarette consumption and their relationship with cigarette price and income can provide valuable information for developing cigarette price policy.

INTRODUCTION

Tobacco use has become the leading cause of preventable death in the world with nearly six million deaths per year and hundreds of billions of dollars of economic losses. If current trends continue, by 2030 tobacco will kill more than eight million people worldwide each year, with 80% occurring in low-income and middle-income countries (LMIC).[1] Argentina is a middle-income country that is among the 10 leading tobacco-growing countries in the world and second in Latin America after Brazil.[2] Smoking prevalence in Argentina was 38.3% for men and 24.5% for women in 2001,[3] but by 2009, smoking prevalence had declined to 32.4% and 22.4% for men and women, respectively.[4] Conte Grande[5] estimated that there were 41 280 deaths attributable to tobacco consumption in Argentina among persons older than 35 years in 2003 which generated a cost by loss of future earnings from premature death of $543 million pesos in 2003.

Some studies suggest that LMIC could reduce 115 million smoking-related deaths by 2050 using a combination of tax increases, advertising bans, informational campaigns, restrictions on smoking in public places and enhanced tobacco dependence treatments.[6] Evidence on the health and economic consequences of tobacco use has led many governments, first in high-income countries and more recently in a growing number of LMIC, to significantly increase tobacco taxes to reduce tobacco use. There are few studies that have evaluated the effect of tobacco taxes on cigarette demand in Latin America and only one study that explored the demand for cigarettes in Argentina.[7] There is currently approved legislation in Argentina that is pending implementation which will prohibit smoking in all indoor public places, prohibit the sale of tobacco products to minors and greatly restrict tobacco advertising. However, proposals to increase taxes on cigarettes have not advanced.

Elasticity is an economic measure that captures the sensitivity of the quantity demanded of a good (cigarettes) with respect to a change in its price. Under normal circumstances, there is an inverse relationship, so when cigarettes are more expensive demand decreases and price elasticity is reported as a negative value. The per cent change in demand for cigarettes as a consequence of price change defines the concept of price elasticity. Income elasticity reflects the ability of the population to purchase the product as per capita income changes. The usual relationship is in a positive direction with capacity to purchase, or demand, increasing as per capita income increases. Analysing and predicting the evolution of cigarette demand are useful in developing an effective tobacco control policy. This paper approaches the problem from an econometric perspective using data from a middle-income country with no plan to increase taxes on cigarettes. Our goal was to conduct an empirical analysis of cigarette demand in Argentina over the period 1994–2010 and to estimate income and price elasticities, which are two factors that drive demand for cigarettes.

Tobacco market in Argentina

The tobacco industry in Argentina is led by two subsidiaries of multinationals Massalin Particulares S.A. of Phillips Morris Co and Nobleza Picardo of British American Tobacco with 97.3% of the national cigarette market. The provinces of Jujuy, Misiones and Salta produced 92% of the tobacco in the country and there has been a 30% increase in land use for cultivation between 1990 and

2009.[8] The economic activity of tobacco farming and production is labour-intensive and generates almost 53 840 jobs.[9]

Tobacco production in Argentina is subsidised through payment to the producer as an overprice on the final cost of storing. In order to finance this overprice, the national government collects the Special Tobacco Fund (*Fondo Especial de Tabaco* or FET) through a specific tax on consumption of 7% and about 80% of this fund is distributed back to the tobacco producers as a state subsidy. The final price of cigarettes in retail markets includes a complex set of different types of taxes that add up to about 70% of the price.[7]

The average real retail price per pack of cigarettes in pesos was stable between January 1994 and December 1999, but since then there have been wide fluctuations from a minimum of \$1.50 in March 2003 to a maximum of \$3.32 in October 2010 (figure 1). The monthly average consumption of cigarettes per person in Argentina for those older than 14 years of age was 126 from 1994 to 2001 and decreased after 2001 to 116. Cigarette consumption in Argentina remains high, but after steadily decreasing from 1994 to 2001 consumption has levelled somewhat at a rate lower than in the 1990s.[10]

METHODS

Data sets

This analysis used the available monthly economic data from Argentina from January 1994 to December 2010. All the variables were seasonally adjusted. Cigarette consumption data were derived from total sales of cigarettes to the public reported by the Ministry of Economics and Production on a monthly basis. No population surveys were available to ascertain cigarette consumption on an individual level. Income data used the gross domestic product (GDP) per person older than 14 years; the price variable was determined by the average price of cigarettes sold to the public that included taxes. Income and price data were adjusted for inflation using the consumer price index. All data except population data were obtained from the Ministry of Economics and Production in Argentina. The population data were collected from the Instituto Nacional de Estadisticas y Censo (INDEC or National Institute of Statistics and Census).[11] Population statistics for estimates of persons older than 14 years were only available annually, and thus were assumed to be a constant growth rate in order to obtain monthly estimates (see online supplementary table A1).

Methodological framework

Much of the empirical literature related to estimates of cigarette demand with time series use a double-logarithmic specification because of the simplicity of obtaining the elasticity under study. After confirming this functional approach as appropriate (see online supplementary section 1), a linear double-logarithmic form using consumption as a dependent variable and income, price and some dummy variables as independent variables was used in the empirical analysis. Therefore, in the empirical study the following specification for the long-term demand for cigarettes was employed:

$$\ln(\mathrm{Qpc_t}) = \alpha_0 + \alpha_1 \ln(\mathrm{RYpc_t}) + \alpha_2 \ln(\mathrm{RP_t}) + \alpha_3 \mathrm{D_t} + \mu_t \quad (1)$$

where $\mathrm{Qpc_t}$ is the quantity of cigarettes consumed and was measured as numbers of cigarettes per person older than 14 years; $\mathrm{RYpc_t}$ is the real income measured as the real GDP in real terms per person older than 14 years, $\mathrm{RP_t}$ is the real average price of cigarettes, α is constant term, $\mathrm{D_t}$ is a group of dummy variables and π_t is an error term. The first dummy variable (*D(age)*) accounts for the introduction of a ban on sales for persons under 18 years old (March 1997). The second dummy variable (*D(control)*) represents the implementation of tobacco control measures such as smoke-free places (with a value of 1 between January 2006 and December 2010, and 0 in all other months). The last dummy variable (Dummy 02) represents a change in the macroeconomic policies (March 2002) to capture any effects of the country's economic crisis in 2001–2002 on cigarette consumption as a consequence of the devaluation of the peso.

In the empirical analysis, we tested for the existence of a long-term equilibrium relationship among the variables (estimation of Equation 1), while the use of the vector error correction model (VECM) captured the short-term dynamics of the variables (see online supplementary section 2, Table A2).

The presence of cointegration among the variables will show the long-term equilibrium relationship described above. VECM represents the short-term movements in the variables. When the error correction term is included in the model, the long term,

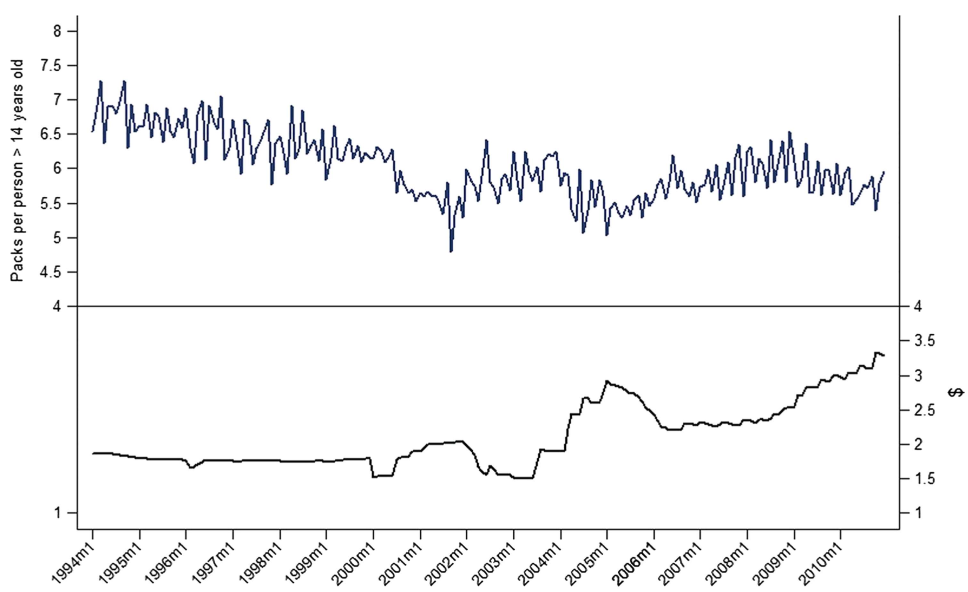

Figure 1 Average monthly consumption and real retail price of cigarettes—Argentina 1994:1–2010:12. The top line shows the average monthly consumption of cigarettes from 1994 to 2010. The bottom line shows the average price of one pack of 20 cigarettes during these years.

or equilibrium stable, relations are accounted for. The Johansen test result implied that there was one cointegration vector among cigarette consumption, income and price (see online supplementary section 3, table A3).

Having verified that a cointegrating relationship existed between the variables, VECM was applied. The error correction term measures the proportion by which the long-term imbalance in the dependent variable is corrected in each short-term period. The size and the statistical significance of the error correction term measure the extent to which each dependent variable has the tendency to return to its long-term equilibrium.

SIMULATION MODEL

We applied the elasticity values derived from the empirical analysis in a simulation model following the example by Hsieh[12] to show the possible impact of increasing the final price of cigarettes on consumption and on revenue from cigarette tax. The initial values for the simulation corresponded to the last quarter of the year 2010. We used 1 month to define short-term time period because we measured the effect on consumption at 30 days of price increase. We used 3 months as long-term time period because this was captured as the short-term dynamic in VECM with data from a rolling 3-month period (two lags or two previous months) being used. The monetary values are in pesos as of December 2010 and the values correspond to the consumption of cigarettes and the revenue from cigarette tax from the last quarter of 2010. The tax increases were modelled as completely transferring to the final retail prices.

RESULTS

The estimated long-term (3 months) demand is summarised in the following equation:

$$\begin{aligned} \ln(\mathrm{Qpc}_t) = & -2.15 + 0.43\ln(\mathrm{RYpc}_t) - 0.31\ln(\mathrm{RP}_t) \\ & \quad (5.75) \quad (7.65) \qquad\qquad (-2.60) \\ & - 0.10\mathrm{D(age)} - 0.05\mathrm{D(control)} \\ & \quad (-11.22) \qquad (-2.91) \end{aligned} \tag{2}$$

where the numbers in parentheses contain the t-statistics. Both coefficients are significant with signs in the expected direction and because we used a double-logarithmic function, the coefficients of the income and price variables represent the long-term elasticity of each. Therefore, the long-term income elasticity was equal to 0.43 and the long-term price elasticity was equal to −0.31, meaning a 10% increase in income will produce an increase in cigarette consumption by 4.3% and a 10% increase in price will produce a decrease by 3.1% in cigarette consumption.

Short-term relationship

In the restricted dynamic cigarette demand presented in table 1, all the estimated coefficients, including the error correction term, are statistically significant and have a sign in the expected direction. The error correction term is equal to −0.82 suggesting that the speed of adjustment is equal to 82%. This means that after the deviation from the steady state, the model adjusts at a rate of 82% in the direction of long-term equilibrium once again. The estimated coefficient for the short-term change of real income is positive and significant and its value is equal to 0.25. This value implies that a 10% increase in the growth of real income will lead to an increase in cigarette consumption by 2.5% in the short term. The estimated coefficient for the short-term effect of the price is statistically significant and is equal to −0.15. This coefficient can be interpreted as the short-term own-price elasticity of cigarette demand. That means a 10% increase in the price producing a fall of 1.5% in cigarette consumption.

Table 1. Short-term relationship*

Variable	Coefficient	t Value
const	0.08	6.17
$\Delta\ln(\mathrm{RP})_{(-1)}$	−0.15	−7.16
$\Delta\ln(\mathrm{RP})_{(-2)}$	−0.08	−076
$\Delta\ln(\mathrm{Qpc})_{(-1)}$	−016	−2.14
$\Delta\ln(\mathrm{Qpc})_{(-2)}$	−0.56	−9.31
$\Delta\ln(\mathrm{RYpc})_{(-1)}$	0,25	2.38
$\Delta\ln(\mathrm{RYpc})_{(-2)}$	0,15	0.71
D(age)	−0.08	−5.98
D(control)	−0.03	−3.82
Error correction term	−0.82	−8.11
$R^2=0.57$		
F-statistic = 30.53		
DW-test = 1.97		
ARCH test = 0.72		
White heteroskedasticity = 0.59		

*Only the restricted error correction equation for cigarette demand is presented. All other equations are available from the authors upon request.

The coefficient of the dummy variable *D(age)*, which captured the effect of the prohibition on cigarette sales to persons under 18 years old was statistically significant and with a negative sign. A similar result was obtained for the dummy *D (control)*, which suggests that these tobacco control policies decrease tobacco consumption.

Simulation model

The results of the simulation model are shown in table 2. The initial values for the last quarter of the year 2010 are shown in the 'Status quo' column and the remaining columns contain information about seven different increases in the final price of cigarettes. The complete simulation that shows the impact of all price increases from 0% (status quo) to 320% is shown in online supplementary figure A1.

From the simulation, we can obtain important information for tobacco control policies. An increase in the final price of 20% can lower the total consumption of cigarette packs by 34.38 million in a quarter and can also generate an increase in the fiscal revenue from cigarette tax of \$282.55 million. On the other hand, a bigger increase in price, for example, of 50% generated a fall in the consumption of cigarettes per person >14 years old of 2.82 packs quarterly and an increase of \$602.02 million pesos in tax revenue. Increasing the price by 110% will produce the maximum cigarette tax revenue and the greatest decrease in total consumption of cigarettes (table 2).

DISCUSSION AND POLICY IMPLICATIONS

This paper examined cigarette demand in Argentina employing monthly data over the period 1994–2010. Cointegration techniques were applied to estimate both long-term and short-term income and own-price elasticity of demand for cigarettes. Finally, the importance of short-term deviations was presented using VECM estimation. The empirical results suggest that in

Table 2 Simulation of alternative increases in cigarette retail price by increased taxes using quarterly data, Argentina, 2010

	Status quo	Long-term own-price elasticity=−0.31						
		Price increase						
	2010 Q:4	10%	20%	30%	40%	50%	60%	110%
A. Average retail price ($)	5.97	6.54	7.16	7.76	8.36	8.96	9.55	12.54
B. Average tax per pack ($)	4.06	4.47	4.87	5.28	5.68	6.09	6.50	8.53
C. Total cigarette consumption in millions of packs	554.58	537.39	520.20	503.00	485.81	468.62	451.43	365.47
D. Changes in C (decrease)	–	(17.19)	(34.38)	(51.58)	(68.77)	(85.96)	(103.15)	(189.11)
E. Cigarette consumption per person >14 years old (packs)	18.18	17.62	17.05	16.49	15.93	15.36	14.80	11.98
F. Changes in E (decrease)	–	(0.56)	(1.13)	(1.69)	(2.25)	(2.82)	(3.38)	(6.20)
G. Revenue from cigarette tax in millions of pesos	2251.59	2399.74	2534.15	2654.59	2761.08	2853.62	2932.19	3115.68
H. Changes in G	–	148.14	282.55	403.00	509.49	602.02	680.59	864.08

Note: US$1=$ 4.01 pesos in December 2010.
Source: own calculations.

the long-term period (3 months) the demand for cigarettes was affected by changes in real income and real price. The value of income elasticity was equal to 0.43, while the value of price elasticity was equal to −0.31. The results of VECM estimation show that the income elasticity in the short term (1 month) in Argentina is equal to 0.25 and the short-term (1 month) price elasticity of the demand for cigarettes is −0.15.

These income and price elasticity results for Argentina fall in between the elasticity estimates made for the other South American countries. Studies of elasticity estimates for cigarette demand in Bolivia for the period 1988–2002 found an income elasticity of 0.71and an own-price elasticity of demand of −0.85.[13] Data obtained from Brazil estimated that the price elasticity of cigarette demand for long term and short term were −0.42 and −0.25, respectively, from 1991 to 2003.[14] An innovative approach estimated income and own-price elasticity of cigarette demand in Chile comparing conventional models with the myopic addiction model. Using the conventional models of long-term demand elasticity, this was equal to 0.23 for income elasticity and −0.21 for own-price elasticity.[15] When the authors applied the myopic addiction model, results for the long-term and short-term own-price elasticity were −0.45 and −0.22, respectively, and results for the income elasticity were 0.22 and 0.11, respectively.[15] Analyses of the demand for legal cigarettes in Uruguay using quarterly time series for the period 1991–2003 showed a price elasticity of −0.55 for the long term and −0.49 for the short term; income elasticity values were 0.73 and 0.65 for the long term and short term, respectively.[16]

Argentina has undergone steady economic expansion with annual growth rates as high as 9% since 2003. Despite this expected expansion of purchasing power, the price of cigarettes has remained stagnant and thus these economic policies may be counterproductive to tobacco control. Although smoking prevalence has decreased somewhat, the potential for greater impact by raising cigarette prices to keep up with per capita income has not been realised. Our estimates of elasticity provide valuable information for policy makers on the possible impact of an increase in final retail price of cigarettes (through a tax) on the amount smoked either by encouraging cessation, delaying initiation or decreasing the amount each smoker smokes (intensity). Raising the price of cigarettes simply to keep up with the expanded economic capacity of the population is recommended as a minimum measure based on these data. However, our results show there is a wide margin to increase the cigarette price without revenues from cigarette tax decreasing.

It is important that public health policy makers make their decisions using information from empirical studies based on their own country's data. Therefore, this paper makes a contribution in two ways by providing the estimation of income and price elasticity for Argentina and by addressing the gap caused by the lack of empirical information on cigarette demand in Argentina.

This policy of increasing cigarette prices through taxation is part of Article 6 of the Framework Convention from WHO that was signed but not ratified by Argentina. The results of the simulation exercise suggest that an increase in cigarette prices would permit the government to increase its revenues from taxes imposed on cigarettes to 38%, while at the same time expecting a decrease in consumption. This would be achieved by raising the price by 110% or slightly more than twice the current price in Argentina.

The results of our analysis and the simulation model suggest that increases in cigarette prices by higher tax in Argentina can be an effective instrument for reducing tobacco consumption. Furthermore, the income elasticity estimates in the long term imply that a substantially higher cigarette consumption pattern would be expected as the real income of Argentineans converges with the income of the households from high-income countries. Finally, Argentina is currently working on different antismoking programmes and policies and trying to implement the Framework Convention from WHO even without formal legislative ratification. Policy makers and tobacco control advocates could benefit from the findings of this study that provides useful

What this paper adds

- Using available public data from the Ministry of Economics and Production of Argentina between 1994 and 2010, this econometric analysis showed that the demand for cigarettes was affected by changes in real income and the real average price of cigarettes.
- Using these values in a simulation exercise showed that increasing the price of cigarettes by 110% through additional taxes would both maximise government revenues and result in a potentially large decrease in total cigarette consumption. This would potentially lead to thousands of saved lives in future.

information on the characteristics of the cigarette market in Argentina and supports proposals to increase taxes.

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Contributors The authors EM, RM and EJP-S meet the authorship conditions described below. Authorship credit should be based on (1) substantial contributions to conception and design, acquisition of data or analysis and interpretation of data; (2) drafting the article or revising it critically for important intellectual content; and (3) final approval of the version to be published.

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Methodological Appendix

Table A1. Descriptive Statistics of Data Sets Obtained from the Ministry of Economics and Production, Argentina

Variable	N*	Mean	Std. Dev.	Min	Max
Cigarettes per person older than 14 years	204	120.71	9.38	95.77	145.63
Packs per person older than14 years	204	6.03	0.47	4.78	7.28
Real retail price	204	2.10	0.46	1.50	3.32
Real income per capita	204	12,803.75	3,099.50	9,456.50	22,545,76

*N= number of monthly data points between 1994 and 2010.

Section 1

Seasonal adjustment and Outliers

The variables were seasonally adjusted and also had to be corrected for the cigarette consumption variable because there were two additive outliers for the months of December 1999 and January 2000. The seasonal adjustment was carried out using the X-12 ARIMA and the correction of outliers with the software TRAMO.

Functional form

To select the correct functional form we carried out the PE test of MacKinnon, White and Davidson described in Verbeek [1] which postulates as the null hypothesis the log-log functional form, which could not be rejected (p = 0.45) therefore a linear double-logarithmic form was used in the empirical analysis.

Endogeneity

To be sure that we are estimating the demand for cigarettes rather than the supply and to clarify the possible problem of endogeneity of price variable, we performed the Durbin, Wu and Hausman test (for this test was used as instrument the monthly series of revenue of indirect taxes for cigarettes) which establishes as the null hypothesis that the variable (price in our case) is exogenous, an hypothesis that was not rejected (χ^2 *(1)=2.11, p=0.14*).

Section 2

Introduction

The long-term equilibrium can be interpreted as a steady state among economic variables (existence of co-integration) and allows for the introduction of short-term changes or error correction mechanism. This shows how different conditions affect the changes in economic variables and thus allows the changes in short-term equilibrium over time to be quantified.

With this goal, the initial analysis verified the stability of the time series data, or that it has a constant mean and variance that are independent of time. Running the regression between variables that are not stationary can result in a spurious outcome. Time series that are not stationary have unit roots that reflect the integration order of the time series. If the variables are not stationary these can be changed to stationary using a simple transformation by taking the difference of adjacent time periods (earlier time period is subtracted from the later time period). The number of times the series must be transformed corresponds to the number of unit roots present in the data generating process underlying the time-series. That is, if a series must be transformed *d* times before it becomes stationary, it contains *d* unit roots and is integrated of order *d*, denoted as I (d). [2-6] The presence of co-integration rules out the possibility that the estimated relationship is spurious.

Engle and Granger [6] showed that in the presence of co-integration there always exists a corresponding error correction representation, which implies that changes in the dependent variable are, a function of the level of disequilibrium in the co-integrating relationship, captured by the error-correction term, as well as changes in other explanatory variables to capture all short-term relations among variables.

Testing Unit Roots

Following the method of Campbell and Perron [7] to test whether the time series contained unit roots, we estimated the three forms of the augmented Dickey–Fuller (ADF) test.[2]:

$$\Delta x_t = \delta_1 x_{t-1} + \sum_{i=1}^{P} \phi_i \Delta x_{t-i} + \mu_t \qquad (1)$$

$$\Delta x_t = \delta_0 + \delta_1 x_{t-1} + \sum_{i=1}^{P} \phi_i \Delta x_{t-i} + \mu_t \qquad (2)$$

$$\Delta x_t = \delta_0 + \delta_1 x_{t-1} + \delta_2 (Time) + \sum_{i=1}^{P} \phi_i \Delta x_{t-i} + \mu_t \qquad (3)$$

where $x_t = \{Qpc_t, RYpc_t, RP_t\}$. The μ_t is assumed to be a Gaussian white noise random error and *Time*=1,…,*T* (the number of observations in the sample) is a term for trend. In Eq. (1) there is no constant or trend. Eq. (2) contains a constant but no trend. Both a constant and a trend are included in Eq. (3). The number of lagged differences, *P*, is chosen to ensure that the estimated errors are not serially correlated.

The results from the unit root tests are shown in Table A2. The first three rows test the null hypothesis that a series follows a unit root process or random walk. This implies it is non-stationary and (possibly) integrated of order one, *I* (1), rather than *I* (0). The second three rows test the null hypothesis that the first difference of a series follows a unit root. If true, one must differentiate the series twice to obtain a stationary process. We found that for all series in Table A2 the null hypothesis of a unit root in the level cannot be rejected. There is evidence that cigarette consumption per capita is stationary, *I*(0), for the ADF regression including a constant and a constant plus trend term (Eqs. 2 and 3).

However, further testing suggested that using the model without constant or trend was the appropriate choice. The constant term and the slope coefficient of the trend term were insignificant. The tests for unit roots in the second differences are rejected, implying that the series is *I*(1) and stationary in their first differences.

Table A2. ADF statistics testing for a unit root

Variable	Augmented Dickey-Fuller		
	Eq-1	**Eq-2**	**Eq-3**
LQpc	-0.76	-2.42	-2.73
LRYpc	3.31	3.28	0.42
LRP	0.82	-0.47	-2.21
ΔLQpc	-25.03**	-25.01**	-24.98**
ΔLRYpc	-6.98**	-7.57**	-14.74**
ΔLRP	-10.96**	-11.00**	-11.07**

All variables are in natural logarithms. The first three rows present the ADF *t*-tests corresponding to tests for unit roots in the levels of the series. The last three rows report the ADF *t*-test results for testing whether the first difference has a unit root. A rejection implies that the first difference of the series is a stationary process. The last three columns refer to Equations (1)–(3) above described, which are ADF regressions with no constant, a constant and a constant plus trend, respectively. The critical values for the *t*-tests at 5% are y -1.94, -2.88 and -3.44, respectively; at 1% they are -2.58, -3.48 and -4.04, respectively. Rejections at the 5 and 1% critical values are denoted as * and **, respectively. The critical values for this table are calculated from MacKinnon [8]. The lag length structure of ϕ_i of the dependent variable x_t is determined using a recursive procedure in the light of a Lagrange multiplier (LM) autocorrelation test (for orders up to 13), which is asymptotically distributed as chi-squared distribution and the value of t-statistic of the coefficient associated with the last lag in the estimated auto-regression.

Section 3

Co-integration Test

To test for co-integration, we used the Johansen-Joselius maximum likelihood approach [5] employing both the maximum eigenvalue and trace statistic. The results from the co-integration test showed that both maximum eigenvalue and trace test statistics imply that there was one co-integration vector among cigarette consumption, disposable income and price.

Table A3. Johansen-Juselius Co-integration Test

Trace Statistics

Null	**Alternative**	**Trace**	**0.05 Critical Value**	**0.01 Critical Value**
r=0	r>=1**	99.79	42.44	48.45
r=<1	r>=2	24.31	25.32	30.45
r=<2	r>=3	7.41	12.25	16.26

Maximun Eigenvalue Statistics

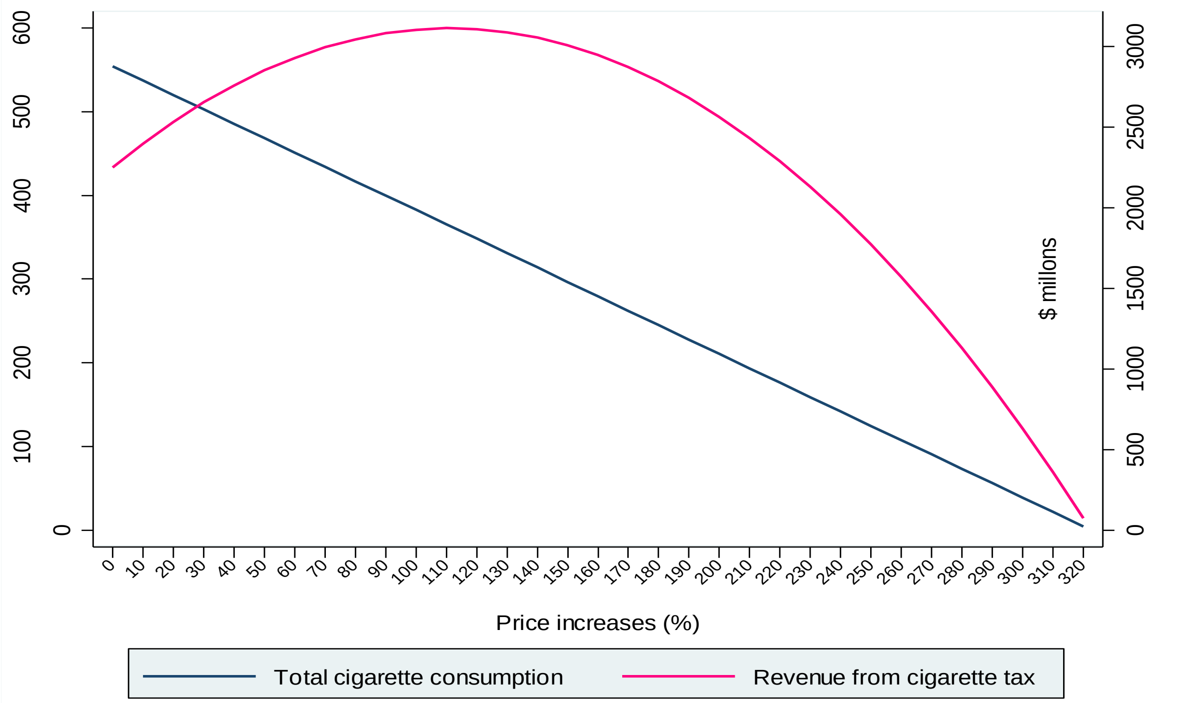
Null	**Alternative**	**Eigenvalue**	**0.05 Critical Value**	**0.01 Critical Value**
r=0	r=1**	75.48	25.54	30.34
r=<1	r=2	19.60	18.96	23.65
r=<2	r=3	7.41	12.25	16.26

r indicates the number of co-integrating relationships. **Denotes rejection of the hypothesis at the 1% level.

Figure A1

Simulation graph

Figure A1: Revenue from alternative rates of cigarette tax and total cigarette consumption



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