

# The use of legal, illegal and roll-your-own cigarettes to increasing tobacco excise taxes and comprehensive tobacco control policies: findings from the ITC Uruguay Survey

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## ABSTRACT

**Background** Little research has been done to examine whether smokers switch to illegal or roll-your-own (RYO) cigarettes in response to a change in their relative price.

**Objective** This paper explores how relative prices between three cigarette forms (manufactured legal, manufactured illegal and RYO cigarettes) are associated with the choice of one form over another after controlling for covariates, including sociodemographic characteristics, smokers' exposure to antismoking messaging, health warning labels and tobacco marketing.

**Methods** Generalised estimating equations were employed to analyse the association between the price ratio of two different cigarette forms and the usage of one form over the other.

**Findings** A 10% increase in the relative price ratio of legal to RYO cigarettes is associated with a 4.6% increase in the probability of consuming RYO cigarettes over manufactured legal cigarettes ( $p \leq 0.05$ ). In addition, more exposure to antismoking messaging is associated with a lower odds of choosing RYO cigarettes over manufactured legal cigarettes ( $p \leq 0.05$ ). Non-significant associations exist between the manufactured illegal to legal cigarette price ratios and choosing manufactured illegal cigarettes, suggesting that smokers do not switch to manufactured illegal cigarettes as prices of legal ones increase. However, these non-significant findings may be due to lack of variation in the price ratio measures. To improve the effectiveness of increased taxes and prices in reducing smoking, policymakers need to narrow price variability in the tobacco market. Moreover, increasing antismoking messaging reduces tax avoidance in the form of switching to cheaper RYO cigarettes in Uruguay.

## INTRODUCTION

Since ratifying the WHO Framework Convention on Tobacco Control (FCTC) in 2004, Uruguay has implemented a comprehensive set of tobacco control policies and become a world leader in the fight against tobacco.<sup>1–3</sup> For example, Uruguay has an ad valorem tax structure based on fixed 'reference' prices that are set by the government and adjusted approximately every 6 months to keep pace with inflation.<sup>4–6</sup> In recent years, cigarette excise taxes have risen several times via the reference price, resulting in a cigarette tax of \$US38

(\$US\$2.3)<sup>i</sup> per pack of 20 sticks as of 2010. In response to rigorous control policies, tobacco usage in Uruguay has been significantly reduced.<sup>1 7–11</sup>

Although Uruguay's tobacco control policies appear to be comprehensive, concerns have been raised regarding tax avoidance and tax evasion that may impede the effectiveness of increased taxes in reducing tobacco use. In recent years, extensive evidence has indicated that many smokers, in particular confirmed smokers, engage in tax avoidance or evasion by switching to cheaper cigarette brands as taxes and prices increase,<sup>11–20</sup> and reducing price gaps may incentivise smokers to trade up to higher-priced cigarettes of better quality.<sup>20 21</sup> In addition, a handful of studies show that smokers may also switch to cheaper tobacco products (eg, roll-your-own, RYO) or different tobacco products (eg, smokeless tobacco) in response to a change in the relative price or tax.<sup>22–26</sup> In Uruguay, owing to its geographically small size and limited price variability,<sup>ii 4 6 27 28</sup> switching down to cheaper RYO cigarettes may be a more feasible way for tax avoidance. According to the Global Adult Tobacco Survey conducted in 2009,<sup>iii</sup> about 32.4% of cigarette smokers in Uruguay smoke RYO cigarettes, compared with only 7.7% in its neighbour country Argentina. While Uruguay has raised its excise taxes on manufactured cigarettes multiple times since 2004, the excise taxes on RYO tobacco have remained substantially lower. Not until 2010 was the tax rate on RYO tobacco raised to 70% (compared to 28–50% in previous years) based on a reference price of \$US24.29 per 45 g package.<sup>iv</sup> (figure 1) Therefore, as excise taxes and prices of manufactured cigarettes have increased markedly, the price of RYO cigarettes has decreased to a great extent relative to manufactured cigarettes, making RYO cigarettes more appealing as an economic alternative. Accordingly, to improve the effectiveness of increasing cigarette taxes as a tobacco

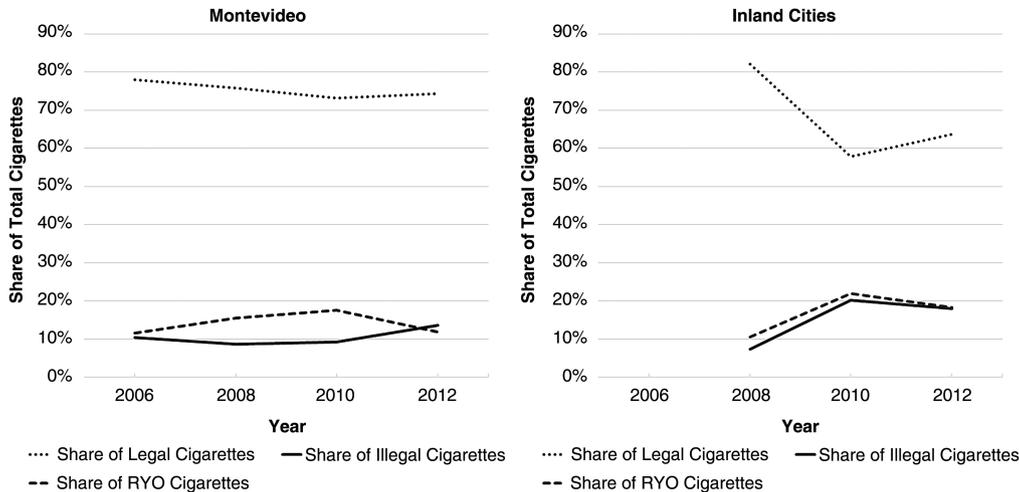
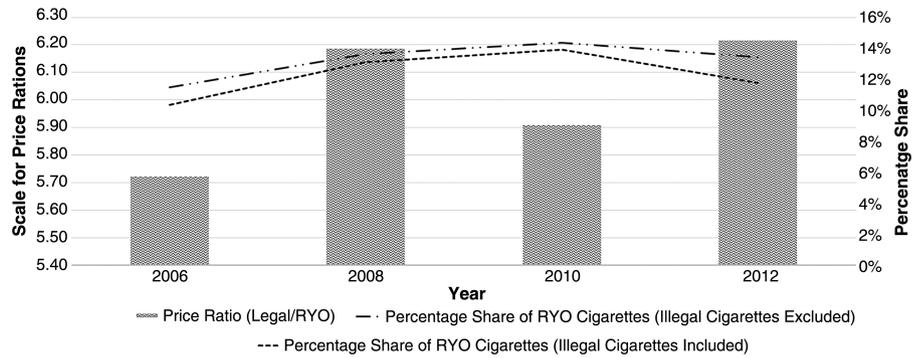
<sup>i</sup>According to the International Monetary Fund World Economic Outlook database, April 2013 edition, 1US\$ is approximately 17 Uruguay dollars in 2010.

<sup>ii</sup>Tobacco excise taxes are imposed through fixed ad valorem rates and reference price, thus, function as specific excise taxes instead of ad valorem ones.

<sup>iii</sup><http://www.cdc.gov/tobacco/global/>

<sup>iv</sup><http://www.euromonitor.com/usa>

**Figure 1** Price ratio and choice of cigarette forms. RYO, roll-your-own.



**Figure 2** Shares of cigarette by form. RYO, roll-your-own.

control tool in Uruguay, studies that focus on analysing tax avoidance behaviours in the form of substitution between manufactured and RYO cigarettes are needed.

(Figure 1: International Tobacco Control (ITC) data suggest that, once based on regular use instead of last purchase, the share of ‘RYO use only’ among the total cigarette use was 10.2% in 2008–2009, 11.6% in 2010–2011, and 9.5% in 2012; and the share of “RYO use only and dual use of manufactured and RYO” among the total cigarette use was 28.3% in 2008–2009, 26.8% in 2010–2011 and 23.2% in 2012).

In addition to switching down to cheaper RYO cigarettes, smokers may also buy cheaper cigarettes in the form of manufactured illegal cigarettes. A recent study suggests that illegal cigarettes constitute 16.8% of consumption in low-income and middle-income countries.<sup>29</sup> In Uruguay, mixed evidence has been found on the prevalence of illegal cigarettes. While contraband sales have been estimated to be 7% of total sales,<sup>30</sup> which is relatively low compared with the world average, a recent study using ITC Uruguay data suggests that the prevalence of tax avoidance/evasion may have been increasing in recent years. The authors of that study used the prevalence of packs without warning labels or standard warning labels as an approximation for tax avoidance/evasion and, as of 2011, 20.5% of packages do not carry standard—or any—warning labels; this is significantly higher than previous years.<sup>17</sup> Analyses on the share of manufactured legal, manufactured illegal and RYO cigarettes in the Uruguayan market also suggest that its share of manufactured illegal cigarettes has been growing markedly since 2008 (figure 2), although the trends of the share of manufactured illegal cigarettes in the capital Montevideo show a somewhat different pattern than the

trends in inland cities (Durazno, Maldonado, Rivera and Salto). In particular, the share of manufactured illegal cigarettes in Montevideo grew from 9.3% in 2008–2009 to 13.7% in 2012.

This paper explores how the relative prices between manufactured legal, manufactured illegal and RYO cigarettes<sup>v</sup> are associated with the use of different cigarette forms after controlling for a comprehensive set of demographic and socioeconomic characteristics and smokers’ exposure to antismoking messaging, health warning labels and tobacco marketing. Specifically, it analyses how the price ratio between two cigarette forms is associated with the choice of one form over another.

## METHODS

### Data

Data are from the International Tobacco Control Evaluation Project (ITC) Uruguay survey, a longitudinal survey designed to evaluate the tobacco control policies advocated by the WHO FCTC.<sup>31</sup> Sampling weights that account for survey non-response were calculated for each wave of ITC surveys.<sup>31 32</sup> So far, four survey waves have been conducted in five Uruguayan cities:<sup>vi</sup> Montevideo, Salto, Maldonado, Durazno and Rivera. The dates of these waves were November to December 2006, September 2008 to February 2009, October 2010 to January 2011, and

<sup>v</sup>We assume all RYO cigarettes are legal because their cheap prices may be a disincentive for smuggling or illegal trade, though only legally obtained manufactured products are referred to as legal in this paper.

<sup>vi</sup>In wave 1, the only city surveyed was Montevideo. Other cities were added in later waves.

September to December 2012. Adult smokers aged 18 years or older were interviewed and their tobacco consumption, tobacco purchase information, exposure to tobacco control policies, exposure to tobacco marketing as well as socioeconomic and demographic characteristics were collected. In particular, the price per cigarette or per pack was derived from the last purchase information. Detailed brand information was used to identify the purchase/use of manufactured legal, manufactured illegal and RYO cigarettes. The average retention rate of the survey was approximately 70%.<sup>33</sup> The wave 1 survey included approximately 900 respondents from Montevideo. With replenishment, approximately 1000 respondents in Montevideo and 400 respondents in each of the other four cities were followed up in waves 2–4. By wave 4, around 16% of smokers had quit.

The tobacco market of Uruguay is an oligopoly dominated by three companies: Cia Industrial de Tabacos Monte Paz SA, Philip Morris International Inc and British American Tobacco Plc share 99% of the legal market, with the domestic company Monte Paz being the biggest player.<sup>34 35</sup> Therefore, any brands that are not owned by these three companies are most likely products from illegal trade, and so are categorised as manufactured illegal cigarettes in this study. A majority of the brands classified as illegal were from Paraguay.

Since the brand of the last purchase was used to define the cigarette form, dual use and the concurrent use of multiple cigarette forms cannot be identified using this approach. The sample used for analysis was restricted to smokers who reported the use of one of the three defined forms: manufactured legal, manufactured illegal and RYO cigarettes (for the latter, there is no distinction between legal or illegal status). Stratified multi-stage design was employed in the survey with sections in each city that correspond to census tracts used as primary strata. Each section was thereafter divided into segments, and then further into units.

### Variables

Four dichotomous dependent variables were constructed to measure smokers' choice of one cigarette form over another, including the choice of RYO cigarettes over manufactured illegal and legal cigarettes, the choice of RYO cigarettes over manufactured legal cigarettes (respondents who used manufactured illegal cigarettes were dropped out of the sample), the choice of RYO cigarettes over manufactured illegal cigarettes (respondents who used manufactured legal cigarettes were dropped out of the sample), and the choice of manufactured illegal over legal cigarettes (respondents who reported RYO cigarette use were dropped out of the sample). These four outcomes were analysed separately on how they are associated with relative price ratios between products, exposure to the tobacco control and marketing environment, and sociodemographic characteristics.

Self-reported prices and exposure to tobacco control policies and tobacco marketing are most likely simultaneously determined with tobacco use behaviours. For example, heavier smokers are more likely to buy cheaper cigarettes. Thus, using self-reported measures of tobacco control policies may lead to an overestimation of the negative association between tobacco control policies and smoking. Meanwhile, coupons, delivery cost and other costs involved in the distribution chain in different locations are likely to vary and most likely lead to exogenous differences in prices by locations. Therefore, to address this simultaneity bias, many previous studies and methodology discussions have suggested analysing aggregated measures of self-reported prices and policy/marketing exposure.<sup>7–10 36 37</sup> Moreover, only the price of the purchased product was reported

by individuals and aggregating prices is necessary to estimate the prices of other products faced by individuals who live in the same location. For the above reasons, price and exposure measures in this study were constructed by aggregating at the segment level, which means that the price is less likely to be endogenous.

Standardised prices<sup>vii</sup> of manufactured illegal, manufactured legal and RYO cigarettes per stick were constructed using median prices by cigarette form, survey wave and segment. For RYO cigarettes, it was assumed that each 'pouch' or 'container' of tobacco provides 72 cigarettes since a standard pouch in Uruguay contains 45 g of tobacco and previous studies indicate that 20 cigarettes are equivalent to approximately 12.5 g of loose tobacco.<sup>38</sup> Thus, a standard pouch is approximately 3.6 packs or 72 sticks of cigarettes. In addition, since the prevalence of manufactured illegal and RYO cigarette use is relatively low, the aggregated prices of these two cigarette forms are not always available for all segments during the survey period. On average, among a total number of 289 segments (around 20 observations per segment), 7 segments were missing prices of manufactured legal cigarettes, 139 segments were missing prices of manufactured illegal cigarettes and 154 segments were missing prices of RYO cigarettes. Therefore, prices of manufactured legal, manufactured illegal and RYO cigarettes were first predicted for each individual in each wave after regressing these prices on strata (division) fixed effects and survey-wave fixed effects, then these predicted prices were aggregated to the segment level using median prices, and in the final step these aggregated predicted prices replaced missing segment-level prices. Doing this utilised the national increment in tobacco prices over the years and strata-specific attributes in tobacco prices to fill in missing prices. The mean minimum to maximum range and SDs of prices before and after filling in missing values were very close.<sup>viii</sup> Price ratios between cigarette forms, including the price ratio of manufactured legal to RYO cigarettes, price ratio of manufactured illegal to RYO cigarettes and price ratio of manufactured legal to illegal cigarettes, were thereafter generated using the corresponding segment-level prices after filling in missing values.

Exposure measures were constructed in the form of indices. In ITC surveys, respondents were asked to report their recent exposure to antismoking messaging in a list of venues (television, radio, papers, posters, bus, billboards, street vendors, stores, restaurants, entertainment venues, supermarkets, bookstores, cinemas and cigarette packs), exposure to tobacco marketing in a list of venues for advertising and promotion (television, radio, papers, posters, bus, billboards, street vendors, stores, coffee shops, discos, supermarket, bookstores, cinemas, sport event, art event, samples, special price offers, gift, logo clothing, email, mail and received mails). Indices were developed by first estimating, for each respondent, the fraction of venues that the respondent has been exposed to, and aggregating these individual-level indices to the segment level using mean indices. The warning label index was constructed at the segment level as the mean of respondents' frequency of noticing

<sup>vii</sup>Price data included data for single cigarettes, packs and cartons. When possible, cartons and packages were disaggregated into single cigarettes using information provided by respondents on the number of packs in a carton and the number of cigarettes in a pack. When this information was not available, it was assumed that there are 10 packs in a carton and 20 cigarettes in a pack.

<sup>viii</sup>Two-sample t test suggests that the means for prices before and after filling in missing values are not significantly different.

warning labels (1, never; 2, once in a while; 3, often; 4, very often). All indices other than the warning label index were scaled by multiplying by a factor of ten.

The socioeconomic and demographic characteristics include gender, age (4 categories: referent 18–24, 25–39, 40–54, and  $\geq 55$  years), highest education achieved (four categories: <middle school-referent, middle school, high school, and >high school), household monthly income<sup>ix</sup> (five categories: \$0–\$4500-referent, \$4501–\$8000, \$8001–\$15 000, >\$15 000, and income is missing), and marital status (four categories: married-referent, separated/divorced/widowed, single and domestic partnership).

## Models

Given that the ITC Uruguay survey is longitudinal, to account for intertemporal correlation, generalised estimating equations (GEE) were used.<sup>32</sup> GEE models extend generalised linear models by adjusting for the correlated data.<sup>39</sup> Logistic link, a binomial family and exchangeable correlation are applied in estimating the model, which can be described in the equation below:

$$T_{it} = \beta_0 + \beta_1 \text{Price\_ratio}_{st} + \beta_2 \text{Environment}_{st} + \beta_3 X_{it} + \text{Year}_t$$

where  $\text{Environment}_{st}$  is a vector of segment-level variables that measure exposure to tobacco marketing and tobacco control policies such as warning labels and antismoking messaging,  $X_{it}$  is a vector of individual-level socioeconomic and demographic characteristics, and  $\text{Year}_t$  is a vector of survey-wave fixed effects with wave 1 (year 2006) omitted. The covariates also include a dichotomous indicator for respondents surveyed in Montevideo, which appears in all waves.

To carry out the analyses, the four dichotomised choice outcomes ( $T_{it}$ ) defined in the variable section were linked to their corresponding price ratios ( $\text{Price\_ratio}_{st}$ ). Specifically, RYO versus others (manufactured legal and illegal cigarettes combined) and RYO cigarettes versus manufactured legal cigarettes are linked to the price ratio of manufactured legal to RYO cigarettes; RYO cigarettes versus manufactured illegal cigarettes are linked to the price ratio of manufactured illegal to RYO cigarettes; and manufactured illegal versus legal cigarettes are linked to the price ratio of manufactured legal to illegal cigarettes. All summary statistics and regressions were weighted using sampling weights. Robust SEs clustered at the segment level were obtained through the analysis.

## RESULTS

Tables 1 and 2 report the variable definition and weighted summary statistics after adjusting for the inter-temporal correlation in the longitudinal survey. Among all users, 12.4% reported using RYO cigarettes. When the use of manufactured illegal cigarettes is excluded, 14% reported choosing RYO cigarettes over manufactured legal cigarettes; and when RYO use is excluded, 12.8% reported choosing manufactured illegal over legal cigarettes.<sup>x</sup> Among all users who do not use manufactured legal cigarettes, 52.5% reported choosing RYO cigarettes over manufactured illegal cigarettes. Price ratio estimates indicate that

the price of manufactured legal cigarettes is about 6 times the price of RYO cigarettes and 2.5 times the price of manufactured illegal cigarettes, while the price of manufactured illegal cigarettes is 2.7 times the price of RYO cigarettes. The sociodemographic characteristics of the four samples are very similar, except that the sample consisting of only manufactured illegal and RYO cigarette users (column 3) shows lower education and income levels. A majority of statistics shows that around 60% of the respondents have either a middle or high school degree, 35% have an annual household income more than \$15 000, 60% are between ages 25 and 54, and 35% are married.

Results from regression analyses are reported in table 3. The effects of price ratios are also shown in elasticities. The estimates indicate that a higher price of manufactured legal cigarettes relative to RYO cigarettes is associated with an increased use of RYO cigarettes over other cigarettes, and a 10% increase in the relative price ratio of manufactured legal to RYO cigarettes is associated with a 4.6% increase in the probability of consuming RYO cigarettes over manufactured legal cigarettes. Relative price ratios pertaining to manufactured illegal cigarettes were not found to be significantly associated with the choice of manufactured illegal cigarettes.

It is worth noting that more exposure to antismoking messaging reduces RYO consumption relative to the consumption of manufactured legal or illegal cigarettes. Given that a significant portion of Uruguayan smokers think RYO cigarettes are less harmful than manufactured cigarettes, this negative association most likely reflects the increase in the percentage of smokers who consider RYO and manufactured cigarettes to be equally harmful. This group increased from 35% of smokers in 2006 to 40% in 2010–2012, in part as a result of a comprehensive anti-smoking campaign launched in 2006 that treats RYO and manufactured cigarettes the same way. Exposure to warning labels and marketing was not found to be significantly associated with cigarette choices.

Smokers who are male, lower than middle-school educated, with a monthly household income of \$4500 or lower, and age 40 or older are more likely to choose RYO cigarettes over manufactured legal products. Smokers who are lower than middle-school educated, with a monthly household income of \$4500 or lower, and older than the age of 18–24 years are more likely to choose manufactured illegal over legal cigarettes. In general, education, age, income and marital status do not appear to be significantly associated with the choice between manufactured illegal and RYO cigarettes. In addition, the higher smokers' education and income are, the less likely they are to choose RYO or manufactured illegal cigarettes over manufactured legal cigarettes. The older smokers are, the more likely they are to choose RYO or manufactured illegal cigarettes over manufactured legal ones.

## DISCUSSION AND CONCLUSION

The results of this study suggest that a higher price of manufactured legal cigarettes relative to RYO cigarettes is associated with an increased use of RYO cigarettes over other cigarettes. A 10% increase in the relative price ratio is associated with a 4.6% increase in the probability of consuming RYO cigarettes over manufactured legal cigarettes. Therefore, it is necessary to narrow price gaps between RYO cigarettes and manufactured legal cigarettes to decrease the odds of smokers switching from manufactured legal cigarettes to RYO cigarettes for tax avoidance. In contrast, a non-significant association between price ratios and choosing manufactured illegal cigarettes suggests that smokers do not switch to manufactured illegal cigarettes as

<sup>ix</sup>In wave 1, the five categories are \$0–\$3500-referent, \$3501–\$7000, \$7001–\$10 000, \$10 001–\$15 000, and missing income.

<sup>x</sup>These are essentially percentages imputed using RYO use/RYO or legal use and illegal use/illegal or legal use.

**Table 1** Variable descriptions

Variables/indicators	Description
Segmental-level price ratio variables	
Price manufacture legal/price RYO	The ratio of segmental-level price of manufactured legal cigarettes to the segmental-level price of RYO cigarettes
Price manufacture illegal/price RYO	The ratio of segmental-level price of manufactured illegal cigarettes to the segmental-level price of RYO cigarettes
Price manufacture legal/price manufacture illegal	The ratio of segmental-level price of manufactured legal cigarettes to the segmental-level price of manufactured illegal cigarettes
Segmental-level policy exposure index	
Antismoking	The segmental-level average of individuals' exposure to antismoking messaging ranges from 1 to 10. Individuals' exposure were measured using the fraction that he/she was exposed to out of a number of antismoking broadcasting venues (TV, radio, etc.), then was multiplied by 10
Warning labels	The segmental-level average of individuals' exposure to warning labels in the past month (1, never; 2, rarely; 3, sometimes; 4, often; 5, very often) ranges from 1 to 5
Marketing	The segmental-level average of individuals' exposure to tobacco advertisements and promotion ranges from 1 to 10. Individuals' exposure was measured using the fraction that he/she was exposed to out of a number of venues (TV, radio, etc), then was multiplied by 10
Individual-level variables	
	Indicators
RYO use only	RYO=1, others=0 Indicator equals 1 if cigarette is RYO, 0 for all other types
RYO or legally manufactured	RYO=1, legal=0, illegal= Indicator equals 1 if cigarette is RYO, 0 if it is a legally manufactured cigarette
RYO or illegally manufactured	RYO=1, illegal=0, legal= Indicator equals 1 if cigarette is RYO, 0 if it is an illegally manufactured cigarette
Illegally or legally manufactured	Illegal=1, legal=0, RYO= Indicator equals 1 if cigarette is an illegally manufactured cigarette, 0 if it is a legally manufactured cigarette
Gender	Male Indicator equals 1 if respondent is male, 0 if respondent is female
Education	<Middle school Indicator equals 1 if respondent has less than middle school education, 0 otherwise
	Middle school Indicator equals 1 if respondent's highest level of completed education is middle school, 0 otherwise
	High school Indicator equals 1 if respondent's highest level of education is completed or uncompleted high school, technical school, teaching school or army/police training, 0 otherwise
	>High school Indicator equals 1 if respondent's highest level of education is completed or uncompleted university attendance, 0 otherwise
Income	\$U0–\$U4500 Indicator equals 1 if respondent's annual household income is less than \$U4500, 0 otherwise
	\$U4501–\$U8000 Indicator equals 1 if respondent's annual household income is \$U4501–\$U8000, 0 otherwise
	\$U8001–\$U15 000 Indicator equals 1 if respondent's annual household income is \$U8001–\$U15 000, 0 otherwise
	>\$U15 000 Indicator equals 1 if respondent's annual household income is greater than \$U15 000, 0 otherwise
Age	Missing Indicator equals 1 if respondent's annual household income is not reported, 0 otherwise
Marital status	18–24 Indicator equals 1 if respondent's age is 18–24, 0 otherwise
	25–39 Indicator equals 1 if respondent's age is 25–39, 0 otherwise
	40–54 Indicator equals 1 if respondent's age is 40–54, 0 otherwise
	55+ Indicator equals 1 if respondent's age is 55 or above, 0 otherwise
Marital status	Married Indicator equals 1 if respondent is married, 0 otherwise
	Separated/divorced/ widowed Indicator equals 1 if respondent is separated, divorced or widowed, 0 otherwise
	Domestic partnership Indicator equals 1 if respondent is in a domestic partnership, 0 otherwise
	Single Indicator equals 1 if respondent is single, 0 otherwise
Fixed effects	
Montevideo indicator	Indicator equals 1 if observation is from Montevideo, 0 for the other cities
Wave 1 indicator	Indicator equals 1 for observation from first wave, 0 for other waves
Wave 2 indicator	Indicator equals 1 for observation from second wave, 0 for other waves
Wave 3 indicator	Indicator equals 1 for observation from third wave, 0 for other waves
Wave 4 indicator	Indicator equals 1 for observation from fourth wave, 0 for other waves

Wave 1 income is coded differently than waves 2–4. Wave 1 uses the containers 'Up to \$U 3500,' '\$U3501 to \$U7000,' '\$U7001 to \$U10 000,' '\$U10 001 to \$U15 000.' Waves 2–4 use 'Up to \$U 4500,' '\$U4501 to \$8000,' '\$U8001 to \$U12 500,' '\$U12 501 to \$U15 000.' RYO, roll-your-own.

prices of legal ones increase. The combined evidence suggests that, as prices increase, consumers in Uruguay are most likely to engage in tax avoidance by switching to RYO cigarettes rather than by switching to manufactured illegal cigarettes.

Although the evidence indicates that smokers do not substitute manufactured legal with illegal cigarettes as prices increase, [figure 2](#) shows an increasing trend of manufactured illegal cigarette use in 2012 for Montevideo. Given that a majority of the study sample is from Montevideo, where the prevalence of manufactured illegal cigarettes is lower than inland cities that share a border with other countries, it is likely that Montevideo

residents had less access to illegal cigarettes, and thus did not respond to price increases by switching to manufactured illegal cigarettes. If the illegal cigarette supply keeps growing in Montevideo, smokers there may be more likely to switch to illegal cigarettes. Therefore, it is important to increase surveillance of illegal cigarettes, especially in Montevideo.

More exposure to antismoking messaging is associated with a greater consumption of manufactured legal cigarettes at the expense of RYO cigarettes. Given that a significant percentage of Uruguayan smokers think RYO cigarettes are less harmful than manufactured cigarettes, smokers who are exposed to

**Table 2** Descriptive statistics of four samples, International Tobacco Control Uruguay waves 1–4

Variable description		Sample components				
		1 RYO=1, others=0	2 RYO=1, legal=0, illegal=.	3 RYO=1, illegal=0, legal=.	4 Illegal=1, legal=0, RYO==.	
Segmental-level price ratio variables						
	Price manufacture legal/price RYO	6.023 (2.251)	5.996 (2.127)			
	Price manufacture illegal/price RYO			2.704 (1.349)		
	Price manufacture legal/price manufacture illegal				2.458 (1.248)	
Segmental-level policy exposure index						
	Antismoking	5.368 (0.041)	5.384 (0.043)	5.292 (0.082)	5.375 (0.046)	
	Warning labels	2.851 (0.012)	2.851 (0.013)	2.848 (0.022)	2.853 (0.013)	
	Marketing	4.421 (0.037)	4.458 (0.039)	4.257 (0.077)	4.427 (0.041)	
Individual-level variables						
	Indicators					
	RYO use only	RYO=1, others=0	0.124 (0.330)			
	RYO or legally manufactured	RYO=1, legal=0, illegal=.	0.140 (0.347)			
	RYO or illegally manufactured	RYO=1, illegal=0, legal=.		0.525 (0.500)		
	Illegally or legally manufactured	Illegal=1, legal=0, RYO==.			0.128 (0.334)	
	Gender	Male	0.475 (0.016)	0.490 (0.017)	0.578 (0.030)	0.426 (0.017)
	Education	<Middle school	0.258 (0.012)	0.238 (0.013)	0.474 (0.029)	0.226 (0.012)
		Middle school	0.351 (0.013)	0.357 (0.013)	0.299 (0.024)	0.359 (0.013)
		High school	0.254 (0.011)	0.262 (0.011)	0.184 (0.020)	0.264 (0.012)
		>High school	0.139 (0.009)	0.147 (0.010)	0.043 (0.010)	0.154 (0.010)
	Income	\$U0–\$U4500	0.118 (0.008)	0.106 (0.008)	0.222 (0.020)	0.097 (0.008)
		\$U4501–\$U8000	0.177 (0.008)	0.174 (0.009)	0.227 (0.017)	0.166 (0.009)
		\$U8001–\$U15 000	0.275 (0.010)	0.271 (0.010)	0.282 (0.021)	0.278 (0.011)
		>\$U15 000	0.344 (0.011)	0.361 (0.012)	0.190 (0.018)	0.369 (0.012)
		Missing	0.087 (0.006)	0.088 (0.007)	0.073 (0.012)	0.088 (0.007)
	Age	18–24	0.180 (0.010)	0.189 (0.011)	0.096 (0.015)	0.194 (0.011)
		25–39	0.328 (0.013)	0.335 (0.013)	0.311 (0.025)	0.332 (0.013)
		40–54	0.291 (0.012)	0.279 (0.013)	0.335 (0.026)	0.290 (0.013)
		55+	0.193 (0.011)	0.187 (0.012)	0.254 (0.024)	0.177 (0.011)
	Marital status	Married	0.344 (0.013)	0.342 (0.014)	0.353 (0.027)	0.346 (0.014)
		Separated/divorced/widowed	0.164 (0.010)	0.155 (0.010)	0.178 (0.019)	0.171 (0.010)
		Domestic partnership	0.190 (0.010)	0.186 (0.011)	0.250 (0.023)	0.176 (0.011)
		Single	0.299 (0.013)	0.313 (0.014)	0.222 (0.021)	0.305 (0.013)
Number of observations			4197	3726	994	3674

Sample weights were used to summarise statistics. Price ratios are constructed using the median self-reported prices at the segment level for each wave. Wave 1 income is coded differently from waves 2–4. Wave 1 uses the containers 'Up to \$U3500,' '\$U3501 to \$U7000,' '\$U7001 to \$U10 000,' '\$U10 001 to \$U15 000.' Waves 2–4 use 'Up to \$U4500,' '\$U4501 to \$8000,' '\$U8001 to \$U12 500,' '\$U12 501 to \$U15 000.' RYO, roll-your-own.

more antismoking information may be more aware of the risk of RYO cigarettes and less likely to use them. Thus, exposure to antismoking messaging appears to help reduce the prevalence of RYO cigarettes over other cigarette use, reducing tax avoidance.

In sum, to improve the effectiveness of raising taxes in reducing smoking, policymakers should aim to narrow price variability and price gaps between products in a tobacco market. In Uruguay, although the 2010 tax increase on RYO cigarettes narrowed the price gap between manufactured legal and RYO cigarettes, the prices of manufactured legal cigarettes have grown faster than the prices of RYO cigarettes during 2010–2012. Thus, a more aggressive tax increase on RYO cigarettes is needed to reduce the price gap. Additionally, increasing the coverage of antismoking messaging will further reduce tax avoidance in the form of switching to cheap RYO cigarettes in Uruguay.

This study is subject to several limitations. First, it used the brand information from the last purchase to identify the use of cigarettes in different forms, and thus could not identify dual or concurrent use of multiple cigarette forms. Therefore, the prevalence of manufactured illegal cigarettes may be underestimated if manufactured illegal cigarettes are purchased less

frequently than legal ones or RYO ones. In addition, it is possible that participants under-report the purchase of illegal cigarettes due to legal concerns, which may bias the results pertaining to manufactured illegal cigarettes. Second, division-level price information was used to predict missing segment-level prices of RYO and manufactured illegal cigarettes, which may result in a limited variation in the segment-level prices of RYO and manufactured illegal cigarettes, and thus non-significant results for the association between price ratios and the use of manufactured illegal cigarettes. Third, all brands that do not belong to the big three tobacco companies were characterised as manufactured illegal cigarettes, which may not be obtained through illegal trade. However, given that the three companies together share 99% of the legal market<sup>35</sup> and most illegal cigarette brands were from Paraguay, this measurement error is limited. Fourth, aggregated policy and price measures were used that could be subject to endogeneity bias induced by segment-level unobserved marketing, messaging and pricing factors.

Despite these limitations, this study contributes to the existing literature on providing evidence on the substitution between manufactured legal, manufactured illegal and RYO cigarettes in

**Table 3** Binomial generalised estimating equation models, choice between legal, illegal and RYO cigarettes

Variable	Binomial model 1 RYO=1, others=0	Binomial model 2 RYO=1, legal=0, illegal=.	Binomial model 3 RYO=1, illegal=0, legal=.	Binomial model 4 Illegal=1, legal=0, RYO=.
Price ratio variables				
Price manufactured-legal/price RYO	1.069** (1.01 to 1.132)	–	–	–
Price manufactured-legal/price RYO	–	1.095** (1.016 to 1.18)	–	–
Price manufactured-illegal/price RYO	–	–	1.052 (0.905 to 1.223)	–
Price manufactured-legal/illegal	–	–	–	1.024 (0.96 to 1.092)
Price ratio elasticity	0.344*** (0.096 to 0.591)	0.459*** (0.193 to 0.725)	0.065 (–0.061 to 0.191)	0.050 (–0.097 to 0.196)
Policy exposure index				
Antismoking	0.899** (0.821 to 0.984)	0.913** (0.836 to 0.997)	0.898 (0.765 to 1.055)	1.089 (0.974 to 1.218)
Warning labels	0.979 (0.76 to 1.261)	0.984 (0.764 to 1.267)	0.993 (0.694 to 1.421)	0.943 (0.718 to 1.238)
Marketing	1.064 (0.959 to 1.18)	1.051 (0.942 to 1.173)	1.027 (0.876 to 1.204)	0.981 (0.86 to 1.119)
Number of observations	4197	3726	994	3674
Demographic variables				
Gender: female	1	1	1	1
Gender: male	4.145*** (2.953 to 5.818)	3.826*** (2.683 to 5.455)	5.564*** (3.545 to 8.733)	0.793 (0.566 to 1.111)
Education: <middle school	1	1	1	1
Education: middle school	0.509*** (0.311 to 0.832)	0.459*** (0.282 to 0.746)	0.832 (0.416 to 1.665)	0.465*** (0.295 to 0.733)
Education: high school	0.477*** (0.292 to 0.779)	0.414*** (0.257 to 0.668)	0.841 (0.456 to 1.55)	0.441*** (0.284 to 0.684)
Education: >high school	0.219*** (0.113 to 0.424)	0.200*** (0.103 to 0.387)	0.526 (0.164 to 1.692)	0.290*** (0.148 to 0.568)
Age 18–24	1	1	1	1
Age 25–39	1.409 (0.787 to 2.522)	1.325 (0.719 to 2.442)	0.887 (0.41 to 1.92)	1.693** (1.035 to 2.769)
Age 40–54	1.775* (0.952 to 3.31)	1.767* (0.94 to 3.321)	0.831 (0.393 to 1.757)	3.016*** (1.718 to 5.293)
Age 55+	2.254** (1.164 to 4.363)	2.208** (1.11 to 4.393)	0.844 (0.373 to 1.907)	2.776*** (1.417 to 5.437)
Income: \$U0–\$U4500	1	1	1	1
Income: \$U4501–\$U8000	0.719 (0.435 to 1.188)	0.690 (0.424 to 1.122)	0.857 (0.447 to 1.643)	0.504*** (0.318 to 0.799)
Income: \$U8001–\$U15 000	0.526** (0.302 to 0.916)	0.474*** (0.273 to 0.822)	0.689 (0.315 to 1.509)	0.497*** (0.3 to 0.824)
Income: >\$U15 000	0.321*** (0.179 to 0.575)	0.288*** (0.165 to 0.503)	0.705 (0.315 to 1.578)	0.263*** (0.159 to 0.435)
Income: missing	0.656 (0.321 to 1.339)	0.635 (0.3 to 1.343)	0.750 (0.358 to 1.57)	0.510** (0.262 to 0.991)
Marital: married	1	1	1	1
Marital: Separated/divorced/widowed	0.652* (0.397 to 1.071)	0.674 (0.392 to 1.148)	0.661 (0.361 to 1.209)	1.167 (0.767 to 1.775)
Marital: domestic partnership	1.425 (0.817 to 2.486)	1.491 (0.858 to 2.591)	1.247 (0.687 to 2.263)	1.467* (0.987 to 2.18)
Marital: single	0.992 (0.579 to 1.701)	1.030 (0.598 to 1.773)	1.081 (0.554 to 2.109)	1.029 (0.619 to 1.71)
# of observations	4197	3726	994	3674

Note: all regressions are weighted using sample weights and also contain control Montevideo dummy and dummies for years 2008–2009 (wave2), 2010–2011 (wave3) and 2012 (wave 4), and indicator for residents from Montevideo. Robust SEs clustered at the segment level are obtained.

\* $p \leq 0.1$ , \*\* $p \leq 0.05$ , \*\*\* $p \leq 0.01$ . ORs and elasticities are reported and 95% CIs are in parentheses. OR= $\exp(b)$ , b is the coefficient. Elasticity=the average of  $d(\log y)/d(\log x)$ . RYO, roll-your-own.

response to a change in relative prices, which has not been well studied. Its results suggest that increasing price ratios or price gaps are associated with switching to cheaper cigarette forms. Therefore, to improve the effectiveness of increasing taxation as

a tobacco control measure, it is necessary to narrow the price gap between products. The results also suggest that consumers in Uruguay are likely to engage in tax avoidance by switching to RYO cigarettes rather than by switching to manufactured illegal cigarettes. However, it is still important to improve the surveillance on illegal trade, given the recent upward trend of illegal cigarette use in the capital city Montevideo.

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### What this paper adds

- ▶ Using Uruguay data, this paper provides evidence on substitution between manufactured legal, manufactured illegal and roll-your-own (RYO) cigarettes in response to changes in their relative prices.
- ▶ A 10% increase in the relative price ratio of manufactured legal to RYO cigarettes is associated with a 4.6% increase in the probability of consuming RYO cigarettes over manufactured legal cigarettes.
- ▶ Antismoking messaging is associated with a lower probability of consuming RYO cigarettes over manufactured legal cigarettes.

**Competing interests** None.

**Patient consent** Obtained.

**Ethics approval** All ITC Surveys were conducted with the approval of the Office of Research Ethics Committee at the University of Waterloo, Canada and the respective internal ethics board for each country.

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