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EFFICACY OF THE TOBACCO TAX POLICY IN THE PRESENCE OF PRODUCT HETEROGENEITY: A PSEUDO-PANEL APPROACH APPLIED TO SPAIN

ABSTRACT

This paper focuses on the substitution effects between different comercial presentations of tobacco in Spain. Concretely, on cigarettes, cigars and RYO. When taxing policies increase tobacco prices these effects might lead changes from more expensive to cheaper products instead of reducing tobacco consumption. We use micro-data for the years 2006 to 2012. We estimate a complete model of demand. The own-price, the income and the cross elasticity of each good are estimated. The results show that the own-price elasticity of cigarettes is low and the income elasticity of cigarettes' demand is very low . Thus in Spain smokers continue to buy cigarettes when the price of cigarettes increases and when cigarette consumers income declines. Moreover the substitutability relationship of cigarettes for cigars and RYO is weak. Thus, cigarettes smokers in Spain are loyal to this product and consider it a normal good. Moreover, cigar consumption presents high own-price and income elasticities, so cigars are luxury goods. Thus unlike cigarettes, cigar sales fall when cigar prices rise or cigar consumers income falls. Finally, RYO and cigarettes are substitutes goods and RYO and cigars are not substitute ones. That means that RYO and cigarettes can satisfy the same need; then to satisfy it the consumers can use almost indistinctibly the one or the other. This is not the case between RYO and cigars.

Key Words: Tobacco control, Taxation, Public Policy, Roll your Own Tobacco

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1. INTRODUCTION

The consumption of tobacco is one of the public health issues that have captured the attention of most countries in the world. The harm of smoking to public health requires active policies to reduce tobacco consumption severely. Price-based policies have been widely implemented in most countries, particularly in the form of taxes and minimum unit pricing.

However, the effectiveness of taxation as a means to reduce tobacco consumption hinges on the sensitivity of the tobacco demand to prices and income. One potential reason for the failure of the tax policy to cut down smoking must be sought in the heterogeneous nature of tobacco itself. Tobacco is a generic term used to describe multiple commercial formats, such as manufactured cigarettes, cigars, roll-your-own tobacco (RYO), pipe tobacco and smokeless forms, such as sniffing and chewing tobacco. Consumers' preferences for these alternative tobacco presentations differ between and within countries, causing divergent demand reactions to income and prices – both to own prices and to the prices of substitute/complementary tobacco categories. In addition to this, in most countries, these alternative forms of tobacco are taxed not homogeneously but very differently.

As a result of these dissimilarities in consumers' preferences and tax levies, unexpected implications of tax policy for tobacco consumption may arise. One of these unexpected/unintended outcomes is that the implemented tax policy might change not the level of consumption but solely its composition. Specifically, if the disparate nature of tobacco is disregarded, a tax rate increase in one tobacco category might leave the total amount of tobacco consumption unchanged (or even augmented), altering only the type(s)

of tobacco smoked. Specifically, the existence of substitution/complementary relationships between the different forms of tobacco could be one of the main causes of the ineffectiveness of taxes in reducing smoking prevalence. This paper tackels with this issue estimating from a pseudo-panel approach own-price, income and cross-price elasticities of Cigarettes, Cigars and RYO tobacco for the case of Spain.

As reported by Gallus et al. (2014), the recent increase that occurred in European RYO consumption is a good example of this phenomenon, as it took place together with a spike in the tax on manufactured cigarettes. Likewise, Gilmore et al. (2014) report that the transfer from cheap cigarettes to RYO that took place in Great Britain in 2001–2008 was due to RYO being taxed at half the level of manufactured cigarettes. Similarly, Fu et al. (2014) confirm that the increase in Spanish RYO consumption between 1991 and 2012 stemmed from strong substitution effects between RYO and manufactured cigarettes[1]. This fact is also corroborated for Uruguay by Curti et al. (2015), who find that a 10% increase in the relative price of legal cigarettes to RYO cigarettes is associated with a 4.6% increase in the probability of consuming RYO tobacco. As we can see, even if scarcerly the literature has already tackled with the topic of the substitution between cigarettes and RYO for different countries. However, as far as we know no one of these works has estimated these substitution effects measuring it through the calculation of the cross-price elasticites of the demand of RYO and the demand of cigarettes with micro-data (which is the most accurate way to measure these changes on consumption, as micro-

[1] Fu et al. (2014) report a change in consumption between manufactured and RYO cigarettes in 1991-2012. For that period, they find that daily consumption per capita of manufactured cigarettes decreased, on average, 3% annually. At the same time, daily consumption per capita of RYO cigarettes increased on average by 14.1% per year. They interpret these changes as a substitution effect alhought they don't calculate elasticities.

data permit a more precise assessment of consumers behaviour than macro-data). Our paper comes to cover this gap in the literature.

As stated by Morris and Tynan (2012), the boom in the use of RYO as an alternative to factory-made cigarettes has induced an increase in the tax burden of the former, which has generated the appearance of "second-round" substitution effects. To be concrete, Morris and Tynan analyse this type of substitution effects between pipe tobacco (still slightly levied) and genuine RYO tobacco in the USA. This "dual use" or "dual purpose" of pipe tobacco has been promoted intentionally by the tobacco industry as a way of avoiding falling sales. Together with this, other substitutes for manufactured cigarettes come in the form of (cheap) low-quality cigarettes as well as smuggled cigarettes. In this respect, Tsai et al. (2005) point out that, when facing an increase in the tax burden of standard cigarettes, smokers practising brand switching seek two types of compensation: one biological and the other economical. The former consists of switching to high-tar and high-nicotine brands to compensate for cutting down the total amount of cigarettes – and additives –inhaled daily as a result of higher cigarette prices. The latter refers to brand changes aimed at maintaining the number of cigarettes smoked per day for a given budget, which is accomplished by accepting the consumption of poorer-quality cigarettes, although they could involve a higher health risk. Besides, as Branston et al (2018) highlighted, another way of compensating the increase of prices is to put less tobacco in RYO cigarettes. In fact, the boosting of cheap cigarettes as a neutralization mechanism of the effects of tax hikes is a technique that was used intensely by the tobacco industry. However, this practice was soon counterbalanced by the setting of minimum unit prices (López-Nicolas, et. al, 2013). The relationship between tobacco consumption and cheap tobacco is studied, among others, by Lee et al. (2009) and Chen et al. (2014). In addition, it is important to bear in mind that switching from one type of tobacco to another may

have health implications and distributive consequences. In this respect, Gilmore et al. (2014) point out that moving to cheap tobacco formats – RYO, cheap brands, etc. – increases health inequalities, as price conscious smokers switch to cheaper brands rather than quit smoking. Moreover, in spite of the extended opinion among smokers that RYO cigarettes are healthier than manufactured cigarettes and that they help people to smoke less (Zachary et al., 2013), there is clear evidence against this perception. For instance, Darrall et al. (1998) and Kok et al. (1993) show that RYO cigarettes contain much more tar and nicotine than manufactured cigarettes. Other authors, such as Benhamou et al. (1985), De Stefani et al. (1994), Engeland et al. (1996) and Menvielle et al. (2004), report that the relative risk of suffering cancer is much higher for RYO smokers than for other smokers.

As for cigars, the literature is also scarce, but there are studies that evaluate if cigars are substitutes for other tobacco formats and in this case we have works that calculate elasticities. For example, Da Pra and Arnade (2009) analyze the own-price and cross-price elasticities of the demand for cigarettes, cigars, chewing tobacco and loose tobacco (RYO+pipe), distinguishing between three types of stores: grocery stores, drug stores and convenience stores. They find significant elasticities, including those of cigars, which vary depending on the type of store. Other authors have also found significant cross-price elasticities for cigars as in Casseus et al (2015) and in Gammon et al (2016). For example, Gammon et al (2016) find that a 10% increase in cigarette price is associated with a 27.3% increase in little cigar sales. Therefore, increasing and equalizing prices for cigarettes and little cigars may motivate cost-conscious smokers to quit instead of switch to alternative tobacco formats. For the case of Spain, Escario and Molina (2004) modeled the optimal fiscal policy on three types of tobacco –virginia tobacco, black tobacco and cigars– finding significant own-price and cross-price elasticities. With respect to the cross-price

effects, they obtain an asymmetric substitution relationship for black tobacco and cigars (-0.28; -1.22). On the contrary, they find complementarity for Virginia tobacco and cigars (0.23; 1.11).

To sum up, to determine the effectiveness of price-based policies in restricting tobacco consumption as a whole, understanding the process of substitution between tobacco categories is vital. As tobacco is an heterogenous product the taxes applied to each type of tobacco have consequences on the consumption of each other, because of the cross-price elasticities between them. These consequences are of main importance on the control of total tobacco consumption through taxes and have not been deeply analysed in the literature. This paper contributes to this literature analysing the cross-price elasticities between different types of tobacco using micro-data and shows how these elasticities must be computed in order to desing an effective tax policy aiming to control total tobacco consumption. To the best of our knowledge, this is the first time that a paper calculates cross-price elasticities between cigarettes and RYO, cigarettes and cigars, and cigars an RYO, with micro-data showing , with a precise measure of consumers behaviour, that increasing the taxes on RYO can have undesirable effects on the total consumption of tobacco due to the cross-effects.

The paper is structured as follows. In the next section we present a revision of tobacco control policy in Spain. Section 3 shows the data and model used for the estimation of the elasticities. Section 4 presents the results and and discusses them, and finally, our reseach is closed with a section of conclusions.

2-TOBACCO POLICY IN SPAIN

Table 1 presents data about the average prices per gram of tobacco of cigarettes, RYO and cigars from 2009 to 2016 in real terms. We can observe that the prices of cigars – the

cheapest commercial presentation per gram of tobacco – decreased slightly during this period (30.43%), the prices of cigarettes increased by 66.31% and the prices of RYO rose by 148.48%. This evolution is related to the different excise duties applied to each commercial presentation of tobacco in each of these years.

As shown in Table 2, the most relevant fact is that the relative price per gram of RYO, which represented 35.08% of cigarettes' price in 2009 and 51.81% in 2016 Therefore, even though RYO is still much cheaper than cigarettes, the differences in prices of these two commercial tobacco presentations are decreasing. This trend is a direct consequence of the changes in the fiscal policy regarding RYO.

Table 1 Evolution of the average prices of 1 gram of the different prices of (in real prices base 2016)

	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2016/2009**
Cigarettes	0.190	0.223	0.252	0.286	0.309	0,314	0,316	0.316	1.66
Cigar	0.046	0.037	0.032	0.030	0.031	0.032	0.032	0.032	0.69
RYO	0.066	0.084	0.121	0.132	0.158	0.169	0.174	0.164	2.48

Source: Agencia Estatal de la Administración Tributaria AEAT; Instituto Nacional de Estadistica INE and own elaboration. Note: Following OECD (2015), In Spain, the weight of tobacco contained in a cigarette is 0.6 grams.

Table 2 Relative prices of 1 gram of tobacco (%)

	2009	2010	2011	2012	2013	2014	2015	2016	**2016/2009**
Cigar/ Cigarettes	0.24	0.17	0.12	0.11	0.10	0.10	0.10	0.10	0.42
RYO/ Cigarettes	0.35	0.38	0.47	0.46	0.51	0.54	0.55	0.52	1.48

Source: own elaboration from AEAT data. . Note: Following OECD (2015), In Spain, the weight of tobacco contained in a cigarette is 0.6 grams.

3. DATA AND MODEL

3.1 Data

In this paper we use annual microdata from the Spanish Household Budget Survey (SHBS) for the period 2006–2012. The SHBS is a representative random sample of Spanish households that includes detailed information on their size, composition and consumption basket. The SHBS has the structure of a repeated cross-sectional survey. One of its main advantages is that it does not have the attrition problem that is usually present in standard panels, thus ensuring the representativeness of the study units as well as the absence of selection bias in the estimates. Its main limitation is the impossibility of observing the behaviour of the same household over time. Consequently, cross-sectional surveys are not appropriate for introducing dynamics into the estimated models. In addition, from an econometric point of view, cross-sectional data do not allow researchers to correct the presence of endogeneity, which is present in the analysis of the demand for certain goods, such as tobacco.

To panelize the repeated cross-sectional surveys, there are two alternatives based on statistical techniques. On the one hand, the statistical matching technique allows the merging of information from different sources, for example several waves of the SHBS (Ruggles and Ruggles, 1974). For each household surveyed in period t, another "similar household" with common characteristics in each of the previous periods would be identified. The linked households would be treated as homogeneous units in the same way as a data panel (Eurostat, 2013). The second alternative is the construction of a pseudo-panel following Deaton (1985). This is the technique applied in this work. In this case, households that share certain constant characteristics (such as the year of birth, ethnicity or sex of the household reference person) or have characteristics that are constant over

time (place of residence, marital status or size of dwelling) are grouped into cohorts. In this way, the individual observations existing in a standard panel are substituted in the pseudo-panel by the subgroup means of the cohorts. These means have an error of measurement that can be ignored if the number of observations that constitutes each cohort is sufficiently large (Browning et al., 1985; Blundell et al., 1994).

The three criteria used in this paper to identify the cohorts were the age of the household reference person[2], the region where the household is located and the population density of the municipality of the household location. We built four groups based on the age of the household reference person, of which the first group consists of households in which the household reference person is below 40 years old. To establish this first threshold, we took into account the age of emancipation of young Spaniards, which is high for cultural reasons as well as for employment opportunities. Like Bernard et al. (2011), we use the region as an identification criterion. In Spain, there are 17 regions with significant differences in population sizes – some of these regions have a very low population density. To ensure an adequate size of the cohorts, we built 9 groups attending to neighbouring regions. The last criterion chosen was the population density of each municipality of residence, distinguishing between densely populated, semi-urban and sparsely populated locations. Table 3 shows the distribution of observations in each of the cohorts. The total number of cohorts used in this paper is 108, with an average size of 200.7 observations. A total of 76% of the cohorts have more than 100 observations, so the sample is large enough to avoid measurement errors in the population means. For illustrative purposes, in Bernard et al. (2011), the aforementioned value stands at 61%.

[2] The household reference person is the member of the family that earns the higher wage, or brigns the higher income to the household.

Table 3. Number of observations in each cohort (average for the period 2006-2012)

	Autonomous Communities	Age of the household reference person	Urban areas	Semi-urban areas	Rural areas
1	Asturias Cantabria Galicia	<=40	185	179	142
		40 to less than 50	227	165	192
		50 to less than 60	255	171	211
		>60	512	273	422
2	Extremadura Castille-La Mancha	<=40	87	53	283
		40 to less than 50	138	69	307
		50 to less than 60	111	46	293
		>60	167	86	546
3	Basque Country Navarre	<=40	354	199	117
		40 to less than 50	318	211	120
		50 to less than 60	324	163	118
		>60	556	261	148
4	La Rioja Castille- Leon Aragón	<=40	258	134	211
		40 to less than 50	287	115	273
		50 to less than 60	298	115	248
		>60	500	175	527
5	Andalusia Ceuta y Melilla	<=40	266	127	228
		40 to less than 50	261	119	209
		50 to less than 60	285	102	161
		>60	406	135	253
6	Community of Madrid	<=40	307	36	28
		40 to less than 50	312	47	44
		50 to less than 60	282	43	18
		>60	387	42	25
7	Canary Islands	<=40	113	102	33
		40 to less than 50	148	100	27
		50 to less than 60	113	87	24
		>60	156	93	20
8	Catalonia	<=40	314	123	59
		40 to less than 50	262	118	71
		50 to less than 60	219	91	52
		>60	382	150	98
9	Valencian Communnity Balearic Islands Region of Murcia	<=40	300	301	193
		40 to less than 50	336	298	190
		50 to less than 60	290	222	187
		>60	460	371	303

Besides, the SHBS does not contain information on the prices of goods and services consumed by households. These data are necessary to estimate our model. The data regarding the prices of the three types of tobacco analysed in this paper come from the official statistics provided by the Spanish Commissioner for the Tobacco Market. We constructed an annual price index for the period from 2006 to 2012, taking as a reference, for each of the three types of tobacco,[3] the prices of the eight best-selling brands. We weighted the importance of each of these brands in their respective market[4]. As the price of tobacco is regulated, for each region, we weighted this price by the regional general index of consumer prices. Regarding the price of the rest of the goods, we used the Spanish general index of consumer prices.

3.2 Model

One of the key issues in analysing the response of the tobacco demand to changes in price and income, as well as the possible substitution effects between different types of tobacco, is the estimation strategy. The two possible options are to estimate separately the demand for each type of tobacco or to use a complete demand model where the demand of all goods are estimated in a simultaneous way. Therefore, one of the most relevant advantages of a complete demand model is that it allows to capture the possible complementarity or substitutability between the different goods in a more rigorous way. This is the reason we use the Almost Ideal Demand System (AIDS) proposed by Deaton and Muellbauer (1980). In addition, a complete demand model is based on an expense function that ensures the consistency of the underlying structure of preferences according

[3] These brands have a share of the market ranging between 70% and 80%.
[4] Therefore, in the market of cigarettes, in the market of cigars and in the market of RYO.

to the economic theory[5]. In its linear formulation, the AIDS model is formed by a system of equations that collect the different goods from the consumer basket of households:

$$w_i = \propto_i + \sum_{j=1}^{n} \gamma_{ij} lnp_j + \beta_i ln\left(\frac{Y}{a(p)}\right) \qquad [1]$$

Where w_i represents the weight of good i in the total consumption. The weights are the following: cigarettes, cigars, RYO tobacco and the rest of the goods. Therefore, we use four consumption equations: three of them model the consumption of the tobacco -cigarettes, cigars and RYO tobacco- and the last one models the consumption of the rest of the goods[6]. Lnp_j refers to the natural logarithm of the price of goods and $ln\left(\frac{Y}{a(p)}\right)$ refers to the natural logarithm of the real income of households. Likewise, parameter $\propto_i$ is the intercept, and γ_{ij} and β_i are, respectively, the slopes of prices and income in the equation of good i[7]. Variable Y represents monetary household income while $a(p)$ denotes a syntethic price index that has been constructed as follows:

$$lna(p) \approx \sum_{i=1}^{n} w_i ln\tilde{p}_i \qquad [2]$$

where $\check{p}_i$ refers to the price index of every item. Therefore, the synthetic price index[8] in equation (2) has been constructed taking into account the price index of each good, $\check{p}_i$, and their respective weights in the total consumption, w_i. As a consequence, every household has their own syntethic price index to compute the household real income.

[5] Specifically, the AIDS model is a flexible functional form that exploits the dual relationships implicit in consumer theory.

[6] The AIDS model is subject to the following restrictions of aggregation, homogeneity and symmetry (see Deaton and Muellbauer, 1980).

[7] γ_{ij} parameter has two index (goods i and j) to show substitution effects between such goods (for example cigarettes and RYO).

[8] In other words $\check{p}_i$ is the average weighted price of the prices of the goods analysed in this paper. Synthetic price indexes are usually used by economists to measure the level of prices in the economy.

As it is shown in equation (2), the AIDS model assume a linear approximations between consumption and income. It is supposed that the greater the household real income the greater the consumption. However, such linear relationship could not be fulfilled. For example, the consumption of some goods could grow up to a certain income threshold and decrease from such a level (see for example Leinsalu, et al, 2011) –quadratic approximation. This is the reason we use in addition the more flexible quadratic AIDS model (hereinafter QUAIDS) proposed by Banks et al. (1997). As you can see, equation [1] is transformed into a model of rank two where a new term enters equation. Specifically, in equation [3] the new term is the square of household income :

$$w_i = \propto_i + \sum_{j=1}^{n} \gamma_{ij} lnp_j + \beta_i ln\left\{\frac{Y}{a(p)}\right\} + \frac{\theta_i}{b(p)}\left[ln\left(\frac{Y}{a(p)}\right)\right]^2 \qquad [3]$$

Where b (p) is a price index. For simplicity, in expression [3] we assume that b (p) ≅a (p). Note that, for the specific case in which parameter $\theta = 0$, expressions [1] and [3] coincide. Therefore, the LAIDS model is a specific case of the QUAIDS model. The main advantage of the QUAIDS model is its greater flexibility and as a result estimations fits better that the LAIDS approach. The simultaneous equations system to be estimated is the following:

$$w_i = \propto_i + \sum_{j=1}^{n} \gamma_{ij} lnp_j + \beta_i ln\left\{\frac{Y}{a(p)}\right\} + \frac{\theta_i}{b(p)}\left[ln\left(\frac{Y}{a(p)}\right)\right]^2 + \sum_{k=1}^{m} \delta_k d_k + \varepsilon_{it} \; [4]$$

Where δ_k is the parameter used to capture the effect of socioeconomics variables on the consumption of the different types of tobacco (housekols size, area of residence etc.). Also e_{it} is the error term of the model. It's well known that key drivers in tobacco consumptions are price and income and both variables are observables in household surveys. But at the same time, there are other factors that are relevant to tobacco

consumption such as tastes, the socio-economic environment in which they live, the structure of households or the way of life. These drivers are specific to each household and in most cases are not directly observable. This is the so-called unobserved heterogeneity that is relevant to try to control it using some proxys (Meng et al, 2014). In equation (4), d_k refers to a set of three variables used for such purpose: household size (number of people who are living in the same household), area of residence (urban versus rural) and the existence of children in the household. In this context, Idris et al (2008) have found for six Western Eurpean countries including Spain that smoking prevalence is highest in urban areas. Likewise, results by King et al (2009) show the significant influence of household composition on children's likelihood to live in homes with adult smokers.

In this paper, we estimate two systems of equations separately: one for the LAIDS model (assuming therefore that $\theta = 0$) and another for the QUAIDS model. In the estimation of both models, it should be considered that parameter γ could be biased because of the endogeneity in the price of tobacco. There is a bias when the value of the parameters do not coincide with their true value. In this context it is not possible to make a rigorous analysis of tobacco demand because interpretation of results is wrong. This endogeneity could be the result of a simultaneity problem if the price and the quantity consumed are determined at the same time. This phenomenon occurs, for example, when heavy smokers react to a hike in the price of their usual brand by buying cheaper ones (Guindon et al., 2015). In other words, smokers alters the tobacco brands they consume in response to changes in prices. In turn, the tobacco industry responds to these behavioral changes by launching cheaper brands onto the market. Additionally, in the estimation of [4], we face a problem of measurement error in both the spending on tobacco, w, and the monetary income, Y. There are two reasons explaining why the spending on tobacco could be

measured incorrectly. One is the problem of infrequency of purchase due to the design of the household survey. This happens, for example, if heavy smokers bought one or several cartons of cigarettes in the weeks prior to the survey and cannot really remember how much they have spent at the time at which they are interviewed. The second reason is that smokers may have incentives to declare lower expenses than their actual ones, or even null expenses, to hide them from other family members. On the other hand, there is evidence that households tend to declare a lower level of income, Y, in the surveys. A significant number of households interviewed by SHBS erroneously believe that the data declared to the survey could be used for fiscal purposes and decide to declare less than what they really earn. This behaviour generates a measurement error problem when AIDS and QUAIDS models are estimated with econometric techniques. The usual way to overcome this problem is to use the total expenditure of households as a proxy for their income (see Poterba, 1994). The total expenditure has been constructed by adding up the expenditure on all goods and services consumed by each household. The reason is that households report expenditure more reliably than income.

In summary, in the estimation of the LAIDS and QUAIDS models, we face a problem of endogeneity due to the possible existence of both simultaneity and measurement errors. For this reason, in this paper, we use the iterated three-stage least-squares (IV-i3SLS) estimator, which is consistent and asymptotically normally distributed – the iterative process minimizes the sum of squared errors. As it's usual in the literature, the endogenous variables are respectively instrumented with the first of their lags. Given that our model is formed by linearly dependent equations, we estimate the three equations relative to tobacco, omitting the rest of the goods from the estimation. However, the parameters omitted from the estimation can be retrieved from constraints (see Deaton and Muellbauer, 1980).

4. RESULTS AND DISCUSSION

Tables 4 and 5 present the results of the estimation of the LAIDS and QUAIDS models. The Breusch–Pagan LM test confirms that 3SLS is preferred to OLS.[9] Both tables offer the results of the joint significance contrast using a χ^2 test. In both cases, the null hypothesis that all the parameters of the model have zero value is rejected. Table 6 shows the elasticities computed from the LAIDS and QUAIDS models[10]. As can be observed, all the parameters are significant and have the expected sign. The comments presented below are focused on the results of the QUAIDS model, due to its greater flexibility in comparison with the linear model.

Among the demand for the different commercial presentations of tobacco analyzed in this paper the one for cigarettes is the most inelastic to its price (-0.33)[11]. Besides, the RYO tobacco has an own price elasticity of -0.64 and, the form of tobacco with the highest own price elasticity are cigars (-0.97). These elasticities are in the range of other results for Spain. Concretely, Escario and Molina (2004) find an own-price elasticity of -0.47 for black-tobacco cigarettes[12] and -0.93 for cigars and Nguyen et al. (2012) find an own-price elasticity for cigarettes of -0.34. There is no evidence, as far as we know, about own-price

[9] We use the command Lmcovreg3 developed by Shehata (2012).
[10] Annex I shows the expressions used to compute price and income elasticities.
[11] Price elasticity measures the responsiveness of the quantity demanded for a good to a change in its own price. In this case price elasticity is -0.33; this means that the consumption of cigarretes has decreased 0.33% when cigarettes prices have increased by 1%.
[12] This a type of tobacco that is dark in color and strong in taste

elasticities of RYO, for the case of Spain, then our paper is the first one estimating it.[13] As for the results for other countries we have to state, following the meta-analysis by Gallet and List (2003) in which they analysed 86 works, that they are characterized by a great dispersion: there are results from -3.12 until 1.41, being 0.48 the average. In fact, these differences are due to the different models estimated, the different kind of data used, the different tobacco productos analysed and the different socio-economic circumstances of each country in the period analysed.

Regarding income elasticity[14], our results show a low one for cigarettes (0.10). This result shows that cigarettes are necessities whose consumption is not very sensitive to changes in income. In relation to cigars, the income elasticity obtained is 1.09, which indicates that cigars are a luxury good[15]. And regarding RYO tobacco the income elasticity obtained is 0.5. Then, the demand for RYO tobacco is more sensitive to the smoker's income than cigarettes. The empirical evidence for the case of Spain has been mainly focused on estimating elasticities with aggregate data, which in the case of income elasticity means that per capita national income is used as an independent variable. Our work uses micro-data, therefore we have used household'income and not national income as an independent variable. Thus, our results are slightly different from those found in the literature; Escario and Molina (2004) found an income elasticity of 0.37 for Virginia cigarettes and 0.69 for cigars and Nguyen et al. 0.48 for cigarettes. To the best of our knowledge there is no evidence for the case of Spain, of income elasticity for RYO[16]. For

[13] And also the literature estimating own-price elasticities of RYO for other countries is very scarce. For example, Hanewinkel et.al (2007) estimated it with aggregated data for the case of Gemany, and Cornelsen and Normand (2003) did the same for the case of Ireland.

[14] Income elasticity measures the responsiveness of the quantity demanded for a good to a change in income. In this case income elasticity is 0.1; this means that the consumption of cigarretes has increased 0.1% when income has increased by 1%.

[15] For the economic science a luxury good is a good for which demand increases more than proportionally as income rises.

[16] And the evidence for other countries is also very scarce, one of the few papers that estimates the income elasticity of the demand of RYO is the one by Cornelsen and Normand (2013). The authors used macro-

other countries, the results of income elasticities of tobacco demand are also very disperse (Gallet and List, 2003): ranged from -0.80 to 3.03 and being 0.42.

Regarding the cross-price effects[17], the results show that cigarettes and RYO tobacco have an asymmetric substitute relationship. A hike of 1% in the price of cigarettes increases the consumption of RYO by 0.035%. However, an increase of 1% in the price of RYO raises the consumption of cigarettes by 0.32%. That is, the degree of substitution of RYO tobacco for cigarettes is approximately 10 times greater than the degree of substitution of cigarettes for RYO. Besides, the substitution between cigarettes and cigars is low, the substitution of cigars for cigarettes being slightly higher than that of cigarettes for cigars. Finally, cigars and RYO tobacco have a symmetric complementary relationship of around -0.2. As far as we know, this is the only work that analyses the substitute relationship between RYO tobacco and cigarettes and RYO tobacco and cigars from cross-price elasticities of demand for each good. It is also the only work assessing cross-price elasticities for cigars and cigarettes and RYO and cigarettes from micro-data[18]. Taking into account the trend of consumption and taxation on cigarettes and RYO tobacco in Spain and many other countries, these results are a main contribution to the literature on tobacco consumption control policies based on taxes.

data (not personal income but national income) and found that for the case of Ireland, RYO tobacco was an inferior good.

[17] The cross-price elasticity measures how much changes the quantity demanded of a given good when the price of a different good (that can be substitute or not for the former) changes by 1%. In this case the cross price elasticity of cigarettes related to RYO is 0.32 ; this means that the consumption of cigarretes has increased 0.32% when RYO prices have increased by 1%.

[18] That are more suitable than aggregated data for assesing consumer's behaviour.

Table 4. LA-AIDS Model. IV-3SLS estimation results

Cigarettes Equation									
lpCigarret	lpRYO	lpCigars	lpRest	lincome	lincome2	Lsize	lrural	ltype	_cons
0.0135162	0.0012943	0.0014043	-0.0162147	-0.0169643	---	-0.0194889	0.0036195	0.0225681	0.0752247
(0.0035)***	(0.0011)	(0.0019)	(0.0057)***	(0.0023)***	---	(0.0070)***	(0.0014)***	(0.0068)***	(0.0268)***
Cigars Equation									
lpCigarret	lpRYO	lpCigars	lpRest	lincome	lincome2	Lsize	lrural	ltype	_cons
0.0014043	-0.0012332	-0.0002782	0.0001072	0.001283	---	-0.0014966	0.002421	-0.0026528	0.0040733
(0.0019)	(0.0007)*	(0.0012)	(0.003)	(0.000)	---	(0.002)	(0.000)***	(0.002)	(0.015)
RYO Equation									
lpCigarret	lpRYO	lpCigars	lpRest	lincome	lincome2	Lsize	lrural	ltype	_cons
0.0012943	0.0018113	-0.0012332	-0.0018723	-0.0024787	---	-0.0046638	-0.000569	0.0055296	0.004778
(0.0011)	(0.0008)**	(0.0007)	(0.0020)	(0.0005)***	---	(0.0017)***	(0.0003)	(0.0016)***	(0.0092)

	R^2	Chi-2 (p-value)
Cigarettes equation	0,2628	191.23 (0.000)
Cigars equation	0,0919	70.81 (0.000)
RYO equation	0,2677	234.13 (0.000)
Overall system	0,2098	169.77 (0.000)
Breusch-Pagan LM Diagonal Covariance Matrix text. Lagrange Multiplier test Ho: OLS versus Ha: 3SLS	67.65504	

Note: (*) significant at the 10% confidence level; (**) significant at the 5% confidence level; (***) significant at the 1% confidence level. lpCigarret:is the logarithm of the expenditure on cigarettes; lpRYO: is the logarithm of the expenditure on RYO; lpCigars: is the logarithm of the expenditure on cigars; lincome: is the logarithm of the householdl's income; lincome2: is the logarithm of the square income; lsize: is the logarithm of the size of the households; lrural: is the logartithm of the household's location (urban or rural); ltype: lis the logartithm of the type of household (single person with children, single peron without children, adults with chidren, adults without children) ; _cons: intercept.

Table 5. QAIDS Model. IV-3SLS estimation results

Cigarettes Equation									
lpCigarret	lpRoy	lpCigars	lpRest	lincome	lincome2	Lsize	lrural	ltype	_cons
0.0143647	0.0015028	0.0018717	-0.0177392	0.041506	-0.058753	-0.0154879	0.0038634	0.0166996	0.0760383
(0.0039)***	(0.0011)	(0.0019)	(0.0057)***	(0.0150)***	(0.0150)***	(0.0071)**	(0.0014)***	(0.0070)**	(0.0268)***
RYO Equation									
lpCigarret	lpRoy	lpCigars	lpRest	lincome	lincome2	Lsize	lrural	ltype	_cons
0.0018717	-0.0011066	0.0000391	-0.0008042	0.007225	-0.0059925	-0.0010805	0.0024404	-0.003255	.0075403
(0.0019)	(0.0007)	(0.0012)	(0.0034)	(0.0063)	(0.0063)	(0.0029)	(0.0006)***	(0.0029)	(0.0155)
RYO Equation									
lpCigarret	lpRoy	lpCigars	lpRest	lincome	lincome2	Lsize	lrural	ltype	_cons
0.0015028	0.0018605	-0.0011066	-0.0022567	0.0037751	-0.00627	-0.0042431	-0.0005373	0.004909	0.0058321
(0.0011)	(0.0008)***	(0.0007)	(0.0020)	(0.0037)	(0.0037)**	(0.0017)*	(0.0003)	(0.0001)***	(0.0092)

	R^2	Chi-2 (p-value)
Cigarettes equation	0.2614	202.93 (0.000)
Cigars equation	0.0953	72.13 (0.000)
RYO equation	0.2739	237.71 (0.000)
Overall system	0.2151	174.63 (0.000)
Breusch-Pagan LM Diagonal Covariance Matrix text. Lagrange Multiplier test Ho: OLS versus Ha: 3SLS	63.44557	

Note: (*) significant at the 10% confidence level; (**) significant at the 5% confidence level; (***) significant at the 1% confidence level. lpCigarret:is the logarithm of the expenditure on cigarettes; lpRYO: is the logarithm of the expenditure on RYO; lpCigars: is the logarithm of the expenditure on cigars; lincome: is the logarithm of the househodl's income; lincome2: is the logarithm of the square income; lsize: is the logarithm of the size of the households; lrural: is the logartithm of the household's location (urban or rural); ltype: lis the logartithm of the type of household (single person with children, single peron without children, adults with chidren, adults without children) ; _cons: intercept.

Table 6. Price and income elasticities

6.a *Linear AIDS* model

	CIGARETTES	CIGARS	RYO	REST OF GOODS
Cigarettes	-0.4156303 (0.0073463)***	0.0611299 (0.000756)***	0.0565879 (0.0007092)***	-1.298549 (0.0161221)***
Cigars	0.2467964 (0.0127089)***	-1.048394 (0.0025091)***	-0.2156555 (0.0111187)***	0.0659259 (0.0034284)***
RYO	0.2430385 (0.0072619)***	-0.2423292 (0.0071263)***	-0.6467687 (0.0104632)***	-0.7089832 (0.0210599)***
Rest of goods	-0.0171442 (0.0000106)***	0.000079 (1.92e-06)***	-0.0019501 (1.71e-06)***	-0.999665 (6.20e-06)**
Income	0.2495855 (0.0092204)***	1.224428 (0.0115695)***	0.5141253 (0.0143189)***	1.01868 (6.27e-06)***

6.b *Quadratic AIDS* model

	CIGARETTES	CIGARS	RYO	REST OF GOODS
Cigarettes	-0.3332937 (0.0084338)***	0.0530176 (0.0015164)***	0.0351777 (0.0015682)***	-0.7946194 (0.0100841)***
Cigars	0.0020882 (0.0025413)***	-0.979423 (0.0016596)***	-0.1913556 (0.0097665)***	-0.1408309 (0.0068166)***
RYO	0.323887 (0.0109135)***	-0.2163615 (0.0063725)***	-0.6354661 (0.0107187)***	-0.4323911 (0.0123892)***
Rest of goods	-0.0204556 (0.0001181)***	-0.0016835 (0.0000618)***	-0.0031439 (0.0000601)***	-0.9798998 (0.0000842)***
Income	0.1085561 (0.0378409)***	1.099413 (1.099413)***	0.5803109 (0.0434487)***	1.019737 (0.0008569)***

Note: (*) significant at the 10% confidence level; (**) significant at the 5% confidence level; (***) significant at the 1% confidence level.

5. CONCLUSION

The elasticities obtained show that Spanish smokers are loyal to the consumption of cigarettes. First, the own-price elasticity of the cigarette demand is low (-0.33). Second, its income elasticity is very small (0.11). Finally, the degree of substitution of cigarettes for RYO tobacco and for cigars is very small (0.32 and 0.002, respectively).

Moreover, focusing only on own-price elasticities, an increase in the price of RYO tobacco would induce a greater reduction in the total tobacco consumption than if the price increased was that of cigarettes. However, the cross-effects between cigarettes and RYO tobacco inform us that policies aiming to reduce the total tobacco consumption must analyse the consumption transfers between the different types of tobacco induced by the differences in their relative prices. This paper confirms the existence of asymmetry in the cross-effects between cigarettes and RYO tobacco: cigarette consumption is slightly sensitive to RYO prices (0.035) whereas RYO consumption is much more sensitive to cigarette prices (0.32).

Traditionally, in Spain as well as in other occidental countries, the taxation of cigarettes has been higher than the taxation of RYO tobacco. However in Spain, since 2003, the excise duties on RYO have increased at a higher rate than those on cigarettes, reducing the differences in the relative prices. The prices in other countries have followed the same trend as the increase in the taxation on RYO tobacco has been a key factor in the anti-smoking policies implemented by different governments to reduce the growth of its consumption. However, the effectiveness of this type of public policy is controversial. First, the average price of RYO tobacco is still much lower than the price of manufactured cigarettes (half the price for the case of Spain), despite the evidence that RYO tobacco

could be more harmful to health than cigarette tobacco. Second, if the cross-effects of prices on the tobacco demand are taken into account, the differences in taxation may not be adequate for the fight against tobacco consumption. In fact, the reduction of the total tobacco consumption may have been less than expected due to the transfer of RYO tobacco to cigarettes. That is, the effectiveness of the fiscal policy in the fight against tobacco consumption has to be evaluated considering the cross-effects between the different types of tobacco.

Therefore, this work shows, that calculating own-price elasticities is not enough. It is also necessary, in order to have precise measures of the effects of taxation on tobacco consumption, calculating the cross-price elasticities of the demand for the different types of tobacco. This is an important issue all over the world. In fact, to assess the effect of tobacco control policies considering only own-price elasticities (as so many works have done) could provide misleading results driving to ineffective tobacco control policies[19]. For the case of Spain, as can be shown in the Annex II, if the prices of all tobacco products analysed in this paper increase by 1% -and we take into account the cross price effects- the reduction on smoking cigarettes is close to zero (-0.007%). For cigars, the reduction on smoking cigars is (-0.079%). And finally, for RYO, the reduction on smoking RYO is (-1.142%). In terms of tobacco control policy, results show that increasing taxation of these three types of tobacco products in the same proportion is specifically effective on reducing RYO smoking, slightly effective on reducing cigars smoking, and almost null on reducing cigarettes smoking.

[19] For the case of Spain the Annex II presents a simulation showing it.

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ANNEX I

Price and income elasticities are computed using the following expressions (Deaton and Muelbauer, 1980; Alston et al., 1994; Banks et al., 1997):

i. Income elasticity in the LA-LAIDS model:

$$\varphi_i^L = \frac{\beta_i}{w_i} + 1 \quad \text{[A1]}$$

ii. Marshallian price elasticities in the LA-LAIDS model:

$$\epsilon_{ij}^{ML} = \left(\frac{\gamma_{ij}}{w_i}\right) - \beta_i \left(\frac{w_j}{w_i}\right) - \delta_{ij} \quad \text{[A2]}$$

iii. Income elasticity in the QUAIDS model:

$$\varphi_i^Q = \left\{\beta_i + 2\frac{\lambda_i}{b(p)}\right\}\frac{1}{w_i} \quad \text{[A3]}$$

iv. Marshallian price elasticities in the QUAIDS model:

$$\epsilon_{ij}^{QL} = \left\{\gamma_{ij} - \left\{\beta_i + 2\frac{\lambda_i}{b(p)}\, ln\left(\frac{x}{a(p)}\right)\right\}\{\alpha_i + \sum_j \gamma_{ij}\, ln(p_j)\} - \frac{\lambda_i\beta_i}{b(p)}\left\{ln\left(\frac{x}{a(p)}\right)\right\}^2\right\}\frac{1}{w_i} - \delta_{ij} \quad \text{[A4]}$$

where is the Kronecker delta, that is, if i = j (own-price elasticities) and otherwise (cross-price elasticities). Using the Slutsky equation, Hicksian price elasticities are computed following these two expressions:

$$\epsilon_{ij}^{HL} = \epsilon_{ij}^{ML} \cdot w_j \epsilon_i \quad [A5]$$

$$\epsilon_{ij}^{HQ} = \epsilon_{ij}^{MQ} \cdot w_j \epsilon_i \quad [A6]$$

ANNEX II

We derive the expressions that allow us to compute the impact of prices on consumption. We start with cigarettes, of which the demand function is , where is the price of cigarettes, is the price of cigars and is the price of RYO tobacco. To isolate the impact of the changes in the prices of these three goods on cigarette consumption, we take the total differential of . Under the assumption of the absence of income effects, we have:

$$x_C = \frac{\partial x_C}{\partial p_C} dp_C + \frac{\partial x_C}{\partial p_R} dp_R + \frac{\partial x_C}{\partial p_{CR}} dp_{CR} \quad [A1]$$

Developing the expression above, we have:

$$dx_C = \frac{\partial x_C}{\partial p_C} \frac{x_C^0}{x_C^0} \frac{p_C^0}{p_C^0} dp_C + \frac{\partial x_C}{\partial p_R} \frac{x_C^0}{x_C^0} \frac{p_R^0}{p_R^0} dp_R + \frac{\partial x_C}{\partial p_{CR}} \frac{x_C^0}{x_C^0} \frac{p_{CR}^0}{p_{CR}^0} dp_{CR} \quad [A2]$$

Therefore, the variation in cigarette consumption is given by:

$$dx_C = \theta_{x_C,p_C} \frac{x_C^0}{p_C^0} dp_C + \theta_{x_C,p_R} \frac{x_C^0}{P_R^0} dp_R + \theta_{x_C,p_{CR}} \frac{x_C^0}{P_{CR}^0} dp_R \quad [A3]$$

where is the own-price elasticity of the cigarette demand, is the cross-price elasticity between cigarettes and RYO and denotes the cross-price elasticity between cigarettes and cigars. Simplifying expression [A2], we obtain:

$$dx_C = x_C^0 \left(\theta_{x_C,p_C} \frac{dp_C^0}{p_C^0} + \theta_{x_C,p_R} \frac{dp_R^0}{p_R^0} + \theta_{x_C,p_{CR}} \frac{dp_{CR}^0}{p_{CR}^0} \right) \quad [A3]$$

Replicating equation [A3] for cigars and RYO, the total differential for cigars, , and RYO, , is given by:

$$dx_{CR} = x_{CR}^0 \left(\theta_{x_{CR},p_C} \frac{dp_C^0}{p_C^0} + \theta_{x_{CR},p_R} \frac{dp_R^0}{p_R^0} + \theta_{x_{CR},p_{CR}} \frac{dp_{CR}^0}{p_{CR}^0} \right) \quad [A4]$$

$$dx_R = x_R^0 \left(\theta_{x_R,p_C} \frac{dp_C^0}{p_C^0} + \theta_{x_R,p_R} \frac{dp_R^0}{p_R^0} + \theta_{x_R,p_{CR}} \frac{dp_{CR}^0}{p_{CR}^0} \right) \text{[A5]}$$

From expressions [A3]–[A5], the impact of a price change on the demand for each type of tobacco can be computed. Table A1 shows this impact with a variation of 1% in the prices of the three tobacco categories analysed. The first column of Table A1 expresses the variation of consumption considering only the effect of the own-price change. In the second column, the total impact is included, that is, the effects of the own-price change and the cross-price effects. As can be observed, the incorporation of cross-price effects into the analysis reduces the impact on the consumption of cigarettes and cigars and increases it for the case of RYO. Specifically, for this simulation of a 1% increase in the price of the three categories of tobacco, the consumption of cigarettes and cigars becomes practically inelastic while, on the contrary, the consumption of RYO increases its elasticity. Therefore, to make an accurate assessment of the fiscal policy aiming to control tobacco consumption, it is necessary to determine both the impact generated by the own price of each tobacco category and those from the cross-price effects generated by the prices of the substitute or complementary tobacco categories. Otherwise, the efficacy of tax policy to cut tobacco consumption may be unsuccesful.

Table A1 Changes in tobacco consumption as a consequence of a simultaneous increases of 1% in prices		
	Calculus with the own-price effect	**Calculus incorporating cross-price effect**
Cigarettes	-0.333	-0.007
Cigars	-0.979	-0.079
RYO	-0.635	-1.142