What Can we Learn about Smoking from 150 Years of Data?

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Abstract

This paper presents a statistical reconstruction of annual tobacco consumption in Italy from 1871 to 2010. Total tobacco consumption is disaggregated into its four major components (cigars, cigarettes, cut tobacco, and snuff) in both physical and monetary terms. Because the tobacco sector was managed by the State from 1862 to 2003, a rich and detailed documentation is available. Using time series properties, dynamic demand models for tobacco consumption are estimated for three separate sub-periods: 1871-1913, 1919-39, and 1946-2010. Price elasticities, estimated over a time period covering about one and a half centuries, belong consistently to a narrow set. We discuss the public policy implications of a seemingly *iso*-elastic tobacco demand function.

Keywords: *Long run, tobacco consumption, price and income elasticity of demand*
J.E.L. codes: *N43, N44, D12, C220*

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1 Introduction

This paper offers a detailed quantitative account of secular trends in tobacco consumption in Italy.

The case of long-term tobacco consumption represents a fascinating research topic for a number of reasons. First, the sector is very well documented. Since the 19th century, the imports, production and sales of tobacco have often been run by governments under a regime of public monopoly which has led to very accurate official documents and budget reports.[1] Second, tobacco is typically a normal good and its consumption generates habits. These two characteristics make its taxation particularly appealing for revenue raising purposes. Third, policy perspectives and individual attitudes towards consumption of harmful goods have changed dramatically over the last 150 years in most countries. Italy constitutes no exception. Italian policy makers of the 19th century were constantly at work to increase per-capita consumption of tobacco, mainly considered as a major source of State revenues.[2] Turning to individual attitudes towards tobacco, the age of the mass print-media was in the 19th century still in its earliest stages and the shift from elite to mass culture was far ahead. Furthermore, the country was then characterized by widespread illiteracy, especially pronounced in the southern regions. As a result, most consumers were totally unaware of such negative effects[3] and public health concerns were not a priority of the time, as it emerges from official documents[4].

Today, tobacco is widely recognized as a harmful good. It represents one of the preventable causes of death in the world; it kills nearly 6 million people each year, including more than 600,000 non-smokers

[1] Madsen (1916) examines the financial and industrial results obtained from the production and sale of tobacco with a special focus on those countries – France, Italy, Austria, Japan, Spain, and Sweden – with a regime of public monopoly.

[2] Public revenues from sales of tobacco accounted for some ten per cent of total public revenues (Ciccarelli, 2012). In an 1878 report to the Parliament (Atti Parlamentari (1878), Allegato no. 7, p. 42), the Italian Minister of Finance Agostino Magliani argued that per-capita consumption of manufactured tobacco in Italy (about 0.6 kilograms) was still too low when compared to that of other European countries (about 2.5 in Belgium, 1.5 in Germany, and 0.8 in France).

[3] Scalzi (1868) represents a pioneering work on the consumption of tobacco and its negative impact on individual health.

[4] In a Parliamentary address delivered in 1911, the Prime Minister Giolitti refused to contemplate banning young people from smoking (as had been done in Japan) on the grounds that it "*would have the immediate effect of making them all smoke, just to enjoy breaking the law with little risk of getting caught.*" Atti Parlamentari (1907), p. 11800.

death from exposure to second-hand smoke[5]. When did things change? The turning point in the way contemporary societies consider tobacco consumption is conventionally identified with the publication of the first Surgeon General's Report of 1964 (U.S. Department of Health, Education and Welfare, 1964).

Figure 1: Per-capita consumption of tobacco in the US, 1880-1995 (pounds)

Source: National Cancer Institute (1998), p. 22.

The Report stressed, for the first time in official publications, the existence of a causal relationship between smoking and lung cancer. The impact of the Terry Report was enormous and its practical effects immediate (Warner, 2014), as the declining trend in per-capita consumption suggests (Figure 1). The echoes of the Terry Report eventually reached Italian policy makers too and tobacco legislation was updated accordingly. Since the mid-1970s, smoking in public places has been banned by law; fines on the advertising of tobacco products, an illegal activity since the early 1960s, rose considerably after 1983. Tobacco packaging warnings were introduced in 1990.[6] The most recent legislation (a law passed in 2003, but in force as of 2005) has prohibited smoking in workplaces, bars, and restaurants. Finally, since

[5] World Health Organization (2011), p. 7.

[6] The recent legislation on tobacco includes Law no. 584, 11 November 1975 (public places and transport); Law no. 428, 29 December 1990 (tobacco packaging warnings); Law no. 3, 16 January 2003, the so called "Sirchia law" after the then Minister of Health (banning tobacco in workplaces, bars and restaurants, in force as of 10 January 2005). The annual reports of the *Istituto Superiore di Sanità* (ISS, Italian National Health Service) provide rich details on the matter. They are available at http://www.iss.it/fumo (last accessed, March 2015).

January 2013, selling tobacco products to individuals under the age of 18 has been declared illegal.[7]

This change of perspective has produced a public policy tradeoff and an economic puzzle. While increasing tobacco consumption is desirable for increasing value added from sales and public revenues from taxation, decreasing tobacco consumption is desirable for reducing social and external costs from smoking. Whether it is possible to both control tobacco consumption and its negative effects and continue to rely on tobacco taxation as a source of public revenues depends on the relationship between demand and price.

This paper provides the following contributions to the literature on tobacco demand. First, we build a new dataset covering 150 years. Second, we estimate price and income elasticities of demand, both for aggregate tobacco and its four major components, for three separate sub-periods: 1871-1913, 1919-1939, and 1946-2010. We find long-run price elasticities of demand for tobacco to be stable in the range -0.62, -0.51 over the years 1871 to 2010. This result is in line with the literature referring to the more recent decades. Moreover, the mean price elasticity of demand is smaller in the most recent sub-period, even though growing health concerns could have triggered a larger responsiveness. Our findings open up the menu of options available to the policy maker facing the problem of tighter budget constraints at times of decreasing tobacco consumption.

The paper is organized as follows. Section 2 presents a review of the literature. Section 3 introduces the new 1871-2010 tobacco dataset. In Section 4 we estimate both the price and income elasticities of demand for aggregate tobacco (Section 4.1), and for its four major component (cigars, snuff, cut, and cigarettes) (Section 4.2). Section 5 discusses the public policy implications of the results and concludes.

[7] The most recent legislation concerns the e-cigarettes phenomenon. E-cigarettes are essentially a battery-powered cartridge that heats a liquid solution with various flavours (with or without nicotine). They are gaining increasing popularity among Italians.

2 Literature review

Schoenberg (1933) is credited with providing the first estimate of the demand function for cigarettes. In its early stages, the econometrics of tobacco mainly consisted in estimating static demand equations. Since the end of the 1950s, most studies on cigarette demand have explicitly addressed the addictive nature of smoking; this has led to the introduction of dynamic aspects in the empirical specification. The main consequences of modeling addiction is that the short and long-run price elasticities of demand can be rather different, because the dependence of current consumption on past consumption implies a lagged demand response to a current price change. In myopic addiction or habit persistence models, for example, current tobacco consumption depends on past consumption; while the impact of current and past choices on future consumption decisions is ignored. Empirical applications of myopic addiction models (Baltagi and Levin 1986, 1992) are mostly based on the works of Houthakker and Taylor (1966) and Pollack (1970); a review is provided by Chaloupka and Warner (2000). Rational addiction models (Becker and Murphy, 1988) acknowledge that rational consumers are aware of their addiction and adjust their long-term consumption trend in an optimal way. The crucial implication is that current smoking depends not only on past consumption levels but also on future expected ones, giving rise to long-run elasticities usually greater than those estimated from myopic models. Tests of the rational addiction model were initiated by Becker *et al.* (1990 and 1994) on aggregate data, and by Chaloupka (1991) on individual data, and have been followed by a sizeable empirical literature.[8] Auld and Grootendorst (2004) showed that aggregate data tend to produce spurious evidence in favor of addiction because they cannot discriminate between addiction and simple correlation in the consumption series. For this reason, addiction models should be estimated on individual data and are therefore not considered in the present study. We instead focus on the information content of aggregate data for an extremely long investigation

[8] Reviews are provided, among others, by Chaloupka and Warner (2000), Gallet and List (2003), Farrelly *et al.* (2005), Adda and Cornaglia (2006).

period.

Concerning tobacco consumption in Italy, the pioneer study with a modern statistical approach is that of Manera (1963), who estimates a static demand model for tobacco with annual time series data covering the period 1900-1960. More recent works tend to highlight the addictive nature of tobacco and extend the analysis to a dynamic framework. Tiezzi (2005) estimates a dynamic model of the demand for tobacco using both (pseudo) panel data at the regional level for the years 1972-2000, and aggregate time series data at the national level on tobacco expenditure for the years 1960-2002. Pierani and Tiezzi (2009) consider the joint consumption of tobacco and alcohol using a set of aggregate annual data covering the period 1960-2002. Other studies consider the demand for tobacco within a demand system approach which uses weak separability for the grouping of goods (Caiumi, 1993; Jones and Giannoni Mazzi, 1996; Rizzi 2000; Rizzi and Balli 2002).

Another strand of literature, focusing on the 19th century, is currently taking its first steps. Ciccarelli (2012) describes the relevant historical sources and provides statistical reconstructions of annual regional tobacco consumption in both physical and monetary terms from 1871 to 1913. Ciccarelli and De Fraja (2014) estimate the demand for tobacco in post-unification Italy using annual data at the provincial level. The current literature on tobacco consumption in Italy is thus characterized by very heterogeneous data, ranging from micro to annual aggregate (sales) data and a variety of econometric models. As a consequence, the empirical findings are often difficult to compare[9]. One contribution of this study is to provide an estimate of the demand for tobacco from a very long-run perspective, using for the various time periods considered the same estimation approach applied to carefully reconstructed homogeneous time series of tobacco consumption.

[9] The need for a meta-analysis comparing the heterogeneous results of the literature concerning the price elasticity of the demand for tobacco motivated the contribution by Gallet and List (2003).

3 The evolution of the institutional settings and the new tobacco dataset

Long-run statistical reconstructions of economic indicators are often difficult, given the paucity of historical information available. The case of tobacco consumption in Italy, with rich and accurate data only up to the early 1980s, constitutes an exception explained by the temporal evolution of the institutional settings behind the tobacco industry, reflecting essentially the rise and decline of State intervention over the last 150 years[10].

The data used in this work refer to the total annual consumption of tobacco and its major components (snuff, cut, cigars and cigarettes), in both physical (kilograms) and monetary (lire/euro) terms. The time period covered runs from 1871 to 2010. Data from 1871 to 1983 were collected from the annual budget reports of the various institutions (*Regía Cointeressata*: 1869-1883, *Azienda dei Tabacchi*: 1884-1927, *Amministrazione Autonoma dei Monopoli di Stato*: 1928-1983) that were from time to time charged with managing the tobacco business. The annual budget reports share a homogeneous structure and contain sales figures referring to both current and previous years, making it easier to preserve the temporal homogeneity of the time series being reconstructed.

Two points need be clarified. First, the proposed "consumption" data are actually (legal) sales data, referring to ordinary sales of manufactured tobacco for consumption in Italy. They refer to the cash payments made by authorized dealers (*tabaccai*) when buying snuff, cut, cigars, and cigarettes at the monopoly sale warehouses distributed over the Italian territory. The sales considered in our dataset do not include those made at special prices to privileged categories (such as merchant and armed sailors, diplomats, and other minority groups). Furthermore, the sales are those "for domestic consumption" as sales of manufactured tobacco to foreign countries (exports) are excluded.

[10] Vetritto (2005) gives a detailed long-run account of the legal and institutional setting of the tobacco sector in Italy.

The last official budget report by the AAMS was published in 1983[11]. For the period 1984-2010 we obtained the data through personal communication with two institutions: the FIT (*Federazione Italiana Tabaccai*, the national association of Italian tobacconists), and the AAMS.[12] The FIT dataset includes annual data for 1970-2000 on aggregate tobacco consumption in both physical and monetary terms. Aggregate tobacco is also disaggregated into its four major components (snuff, cut, cigars, and cigarettes). The AAMS dataset includes exactly the same information, but for the years 1994-2010. However, we were at least able to perform a set of reassuring consistency checks[13]. The tobacco dataset used in this paper borrows from the FIT dataset the quantitative information for the years 1983-1993, and from the AAMS dataset those for the years 1994-2010.

The full dataset covers the period 1871-2010, and includes 10 annual time-series on tobacco consumption: two series refer to aggregate tobacco (per-capita physical consumption and real price); the remaining series refer to the per-capita consumption and real price of its four major components – snuff, cut, cigars, and cigarettes. Two additional variables enter the dataset: real income, and real private consumption expenditure.

The real price of tobacco was computed by deflating its nominal price by the ISTAT consumer price index (1913=1).[14] The nominal price of tobacco is in fact its unit value, evaluated by dividing the nominal expenditure on tobacco by the corresponding physical consumption. Real income was obtained by deflating Baffigi's GDP series (2011) by the CPI provided by ISTAT (2011). Total current expenditure

[11] However the accompanying text is typically terse and does not allow one to reconstruct temporally homogeneous series of aggregate tobacco consumption and, *a fortiori*, of their major components. Annual reports of the AAMS for selected years are available at http://www.aams.gov.it/site.php?id=2455 (last accessed March 2015).

[12] To have an idea of the wide diffusion over the Italian territory of the FIT network, consider that in the year 2000 there were about 60,000 authorized dealers (*tabaccai*). Given a national territory (net of forests) of around 233,000 square kilometers, the density of *tabaccai* is quite high (60/233).

[13] First, we compared the 1970-1983 FIT data against those reported in the official standard annual budgets of the AAMS. The comparison was made separately for each component of total tobacco sales (snuff, cut tobacco, cigars, and cigarettes), in both physical and monetary terms, separately by years. Second, we compared the AAMS data against the FIT data on total sales of tobacco for the years 1980-1994. Finally, we compared the 1984-2010 data against the figures published annually by ISTAT (*Italian National Institute of Statistics*).

[14] The consumer price index (1913=1) is reported in Istat (2011), p. 896.

for private consumption is also taken from Baffigi (2011). All estimations use per-capita variables. Annual 1871-2010 population figures refer to individuals aged 15 or more and were obtained by a linear interpolation of census data[15].

Figure 2 illustrates secular trends of per-capita tobacco consumption (C), of its real price (P), and real income (Y) normalized by their own means. From end to end, per-capita consumption doubled, rising from about one to about two kilograms. But the story is not one of a steady increase. Per-capita consumption declined considerably from 1871 to 1913; it then fluctuated widely around a constant mean in the inter-war period, to rise at an unprecedented pace from 1945 to 1985, when it reached its highest level ever.[16] The positive trend was reversed in the early 1980s and from 1985 onwards, per-capita consumption declined to the level of the 1970s.[17] Moreover, except for the years 1900 to 1919, there is a negative relationship between tobacco prices and consumption levels. This regularity is not obvious when dealing with goods like tobacco, triggering habits or addictions and it corroborates our choice to specify demand function that do not explicitly account for addiction.[18] Comparing Figures 1 and 2, two points emerge. First, a long-term decline in per-capita tobacco consumption occurred both in the US and in Italy after almost one century of consumption growth. Second, the turning-point in the trend occurs in

[15] Data and intermediate estimation results are available from the authors upon request.

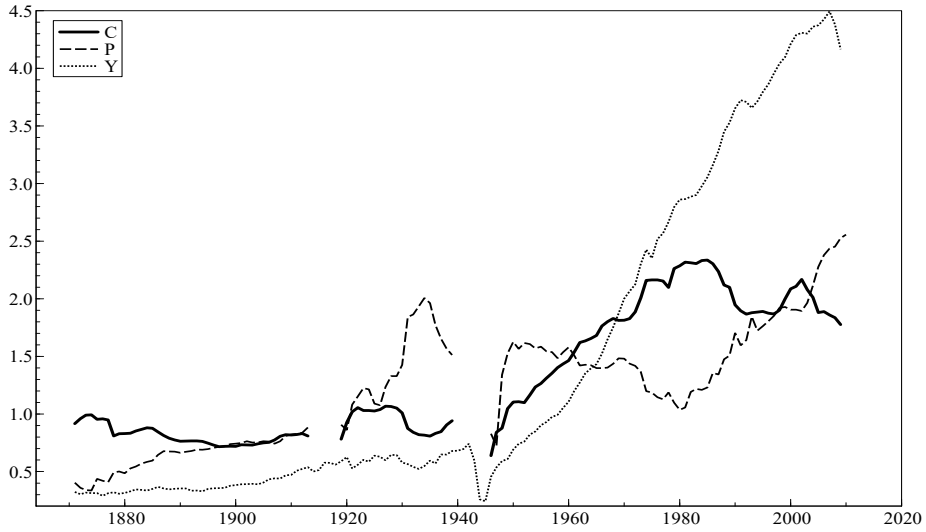
[16] The inter-war years registered a general reduction in international trade. For Italy, autarchy represented the new faith. The historical sources clearly show that the Italian imports of tobacco (both the leaves and the manufactured products) fell considerably during the inter-war period.

[17] The rapid upturn occurring after the turn of the century admittedly appears odd. An explanation can be found in Joossens and Raw (2008), pp. 401-402. The authors provide estimates of the amount of seized tobacco (in tons) in Italy around the turn of the century and find that from 1998 to 2002 legal cigarette sales increased by 19% in Italy as a whole, by 121% in Campania, and by 55% in Apulia. They conclude that illicit cigarette sales became largely unavailable during this period, forcing smokers to buy cigarettes in legal markets. On estimating price elasticities when there is smuggling, see Gruber et al. (2003).

[18] Our data do not detect smuggling. Publicly available data on smuggling are scarce (Gilmore *et al.,* 2013) and, in the Italian case, they refer only to the most recent years (Gallus *et al.,* 2003). The available information suggests that smuggling in Italy increased in the late 1980s, accounting for 10% to 30% of cigarette sales in the early 1990s (Gallus *et al.,* 2003 and 2009). It then declined one decade later due to an increased control of the supply chain of cigarettes and to new decrees on smuggling enforced in the early 2000s, but also to the NATO intervention in Kosovo in 1999 leading to stricter control of the Italian coasts (Gallus *et al.,* 2011). From the year 2000 onwards, the interest in reliable smuggling data grew rapidly in Europe (Joossens *et al.,* 2012), leading to useful data collection. However, the time span of these data is too recent to apply to the present study.

the mid-1960s for the US and the mid-1980s for Italy, a delay of about two decades.

Figure 2: Secular trends in *C*, *P*, and *Y*



4 Empirical results

The aim of this section is to estimate short and long-run price and income elasticities of tobacco demand in Italy from post-unification years to date.

Section 4.1 deals with the empirical analysis of aggregate tobacco demand, based on cointegration tests and an error correction mechanism (Engle and Granger, 1987; Johansen, 1988). In Section 4.2 we further explore the pattern of consumption of the four major tobacco components (snuff tobacco, cut tobacco, cigarettes and cigars) by estimating a complete demand system. The purpose is to provide additional insights for the seemingly iso-elastic demand function we observe over one and half centuries.

4.1 Aggregated Analysis

We proceed in two steps. First, the time series properties of the variables are examined to determine their

order of integration, and a long-run relationship of tobacco demand[19] is then estimated via OLS:

$$C_t = a_0 + a_1 Y_t + a_2 P_t + u_t \qquad (1)$$

where C_t and P_t represent per-capita consumption and real price of tobacco, respectively, and Y_t denotes real per-capita income (see Figure 2). The stationarity of the OLS residuals - verified with unit roots tests - is considered evidence of an equilibrium relationship between *C*, *Y*, and *P* that are said to be "cointegrated". In the second step, the residuals of the cointegrating regression are used as explanatory variable in an error correction model (ECM, henceforth):

$$\Delta C_t = b_0 + b_1 \Delta Y_t + b_2 \Delta P_t + b_3 \hat{u}_{t-1} + \varepsilon_t \qquad (2)$$

where the parameter b_3 of the error term $\hat{u}_{t-1}$ measures the extent to which consumption tends to revert to long-run equilibrium. Table 1 complements Figure 2 and provides descriptive statistics for physical consumption of tobacco (C) in Kg, real per-capita income (Y) in Euros, and real price of tobacco (P) in Euro/kg.

Table 1: Descriptive statistics[a]

Variable	1871-1913		1919-1939		1946-2010	
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
C_t	1.621	0.117	1.673	0.184	2.430	0.491
P_t	0.006	0.001	0.014	0.004	0.016	0.004
Y_t	0.741	0.138	1.060	0.077	3.310	1.486

[a]For a detailed description of the variables see Section 3.

4.1.1 Stationarity tests and cointegration analysis

To determine whether the model variables are stationary and their order of integration, two alternative

[19] The empirical literature provides different specifications of the demand functions (Cameron, 1998, Gallet and List, 2003). The linear form is here preferred to the more popular double-log specification because it is not bound to having constant elasticities. This seems a hardly tenable assumption, when using very long time-series data, and factors that influence tobacco demand responsiveness have possibly changed, even considerably.

tests are used: ADF (Dickey and Fuller, 1979) and KPSS (Kwiatkowski *et al*., 1992) unit root tests. The ADF test consists of running the following regression:

$$\Delta y_t = \mu + \lambda t + \alpha y_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta y_{t-i} + \varepsilon_t \qquad (3)$$

and testing whether the coefficient of y_{t-1} is zero, i.e., $H_0 : \alpha = 0$ versus $H_1 : \alpha < 0$. The number of augmenting lags p is chosen so as to ensure white noise disturbances. The optimal lag length is selected according to modified Akaike (*AIC*) and Schwartz (*SC*) information criteria (Ng and Perron, 2001)[20].

If the null of a unit root cannot be rejected, the test is repeated on the differenced series to check whether one can reject a higher order of integration in favor of *I*(1).

The KPSS unit root test differs from ADF test in that the series y_t is assumed to be stationary under the null hypothesis[21]. The results of both types of tests appear in Table 2. [22]

Table 2: ADF and KPSS unit root tests [a]

Variable	1871-1913				1919-1939				1946-2010			
	ADF		KPSS		ADF		KPSS		ADF		KPSS	
	Lag	Test statistic	Lag	Test statistic	Lag	Test statistic	Lag	Test statistic	Lag	Test statistic	Lag	Test statistic
C_t	5	-1.754	3	0.226***	1	-1.899	2	0.412*	2	-1.487	3	0.389***
ΔC_t	1	-4.679***	3	0.047	1	-2.880**	2	0.219	5	-4.263***	3	0.078
P_t	3	-2.053	3	0.240***	1	-1.418	2	0.618**	3	-0.322	3	0.347***
ΔP_t	4	-5.501***	3	0.096	1	-2.461**	2	0.213	7	-5.906***	3	0.185
Y_t	3	-0.315	3	0.244***	1	-1.631	2	0.102	3	-1.726	3	0.335***
ΔY_t	2	-5.733***	3	0.081	1	-3.960***	2	0.177	1	-3.436**	4	0.136*

[a]: ***, **, * Significant at 1%, 5%, and 10% level, respectively. The number of augmenting lags is selected according to modified *AIC*.

[20] The critical values of the *t*-statistics as well as the relevant *p*-values are based on MacKinnon (1996).
[21] The critical values of this test are based on Sephton (1995).
[22] The results for the second period (1919-1939) are reported for the sake of completeness. They are based only on 21 observations, which makes any conclusion in principle weak. Nonetheless, with the caution of the case, the results of both type of tests show that the three series are nonstationary in the intermediate sub-period, too.

The two test statistics indicate that the levels of the three series are non-stationary. In contrast, when the first difference of the variables is examined, the null hypothesis of a unit root process can be strongly rejected. Therefore, both tests indicate consistently that the variables C_t, P_t, and Y_t are best described as nonstationary I(1) series[23].

Given that C_t, P_t, and Y_t are nonstationary I(1) series, we initially estimate Equation (1) via OLS. Cointegration is supported if the null of a unit root is rejected for the OLS residuals. The estimated long-run relationship is shown in Table 3. Both real price and income variables confirm sign expectations and significantly determine tobacco consumption in Italy in each sub-period. Previous econometric studies (Chaloupka and Warner, 2000; Saffer and Chaloupka, 1999) find negative and significant effects of qualitative and control policy variables (*e.g.*, smoking restrictions, ban on smoking for minors, health information, warning labels on packaging, and demographic factors) on tobacco consumption. Accordingly, we have modelled such a potential impact adding *ad hoc* dummies and a time trend in the long-run regression. These proxies, however, were not statistically significant, and eventually they were dropped to save degrees of freedom.[24]

Table 3: Estimated Cointegration Relationships[a]

Variable	1871 – 1913	1919 – 1939	1946 – 2010
Constant	-1.823***	1.106***	2.786***

[23] In presence of a structural change, though, the ADF-type tests cannot be considered conclusive in that they are known to be biased towards the non-rejection of the null. Hence, we have formally tested for unit roots in presence of structural instability (Perron, 1989). The results, available upon request, reveal that the unit root hypothesis receives support (at the 5% significance level) after considering a structural change effective at 1980. The break date coincides with a rapid increase in the real price of tobacco (see Figure 2). Plausibly, it also reflects the (much delayed) impact of international tobacco legislation and smoking restrictions of the early 1960s on Italian consumers.

[24] The role of smuggling is also of concern. In the absence of available data, one way to control for smuggling when using a time series of aggregate data is to add the price of tobacco products in neighbouring states among the explanatory variables of the demand equation, as in Baltagi and Levin (1986). Other studies have made use of smuggling indices (Becker, Grossman and Murphy, 1994) or proxies (Tiezzi, 2005). In an attempt to control for smuggling, we added among the explanatory variables the aggregate quantity of foreign tobacco, in inverse ratio, used as a proxy of smuggling for the years 1972-2000. However, we did not get significant results.

P_t	-155.451***	-27.778***	-78.935***
Y_t	1.080***	0.417**	0,338***
$\overline{R}^2$	0.842	0,928	0.866
F-statistic	90.381***	93,519***	86.430***
Diagnostic Tests	**Value**	**Value**	**Value**
Serial correlation	6.361***	0.975	46.495***
Normality	0.496	1,428	1.184
Misspecification	0.567	0.441	0.698
Stability	0.511	-1.446	-1.330

[a]: ***, **, * Significant at 1%, 5%, and 10% level, respectively.
Serial correlation: Breusch-Godfrey test; Normality: Doornik-Hansen test;
Misspecification: Ramsey RESET test; Stability: Harvey-Collier *t*-statistic.

The residual based ADF and KPSS test statistics are reported in Table 4. They consistently indicate that the null of non-stationarity of the residuals from the long-run relationship can be rejected at the 5% level in the both the first and second periods and at the 10% level in the more recent period (1946 – 2010). Hence, based on the stationarity of the OLS residuals it can be concluded that C_t, P_t, and Y_t are cointegrated.

Table 4: ADF and KPSS test of estimated residuals[a]

Statistic	Lag	**1871 - 1913**	Lag	**1919 – 1939**	Lag	**1946 – 2010**
ADF	2	-3.952**	5	-3.105**	4	-2,733*
KPSS	3	0.059	2	0.120	3	0.109

[a]: ***, **, * Significant at 1%, 5%, and 10% level, respectively.
The number of augmenting lags is selected according to modified *AIC*.

There could be in principle multiple linear combinations of these variables which are I(0). In order to determine the number of cointegrating vectors, we next use the Johansen approach. The results of the trace test and the maximal eigenvalue test are in particular summarized in Table 5. In both the first and the last sub-periods, the two statistics indicate that we can reject the null of no cointegrating relationships

at the 1% significance level, and suggest that there exists only one stationary relationship between the nonstationary variables included in the model. This finding supports the single equation Engle-Granger approach.

Table 5: Johansen cointegration test[a]

Hypothesis		1871-1913 Test statistics			1919-1939 Test statistics			1946-2010 Test statistics		
H_0	H_1	Eigenvalue	Trace	λ - max	Eigenvalue	Trace	λ - max	Eigenvalue	Trace	λ - max
r = 0	r ≥ 1	0.531	40.245***	28.780***	0.815	49.150***	32.017***	0.382	38.856***	25.499***
r ≤ 1	r ≥ 2	0.217	11.465	9.309	0.559	17.133*	15.545*	0.219	13.356	13.128
r ≤ 2	r ≥ 3	0.055	2.156	2.156	0.080	1.588	1.588	0.004	0.228	0.228

a: ***, **, * Significant at 1%, 5%, and 10% level, respectively.
r indicates the number of cointegrating relationships. Critical values are obtained via Doornik's gamma approximation (Doornik, 1998).

4.1.2 Error correction model

We next turn to the estimation of the error correction model (Engle and Granger, 1987). Table 6 reports the OLS estimates. Given that all variables are stationary, the standard test statistics do have the conventional limit distributions. All relevant coefficients have the expected sign and are statistically significant, with the exception of ΔY_t, which, in the first period (1871–1913), does not affect significantly the changes in tobacco consumption. Changes in lagged consumption ΔC_{t-1}, price ΔP_t, and income ΔY_t (in the recent sub-period) are all statistically significant at 1% and 10% level, respectively. The estimated ECM coefficients are negative and significant in both periods, indicating that the null of the cointegrating hypothesis is not rejected at the 5% level, and that the demand of tobacco partially reverts to long-run equilibrium after any short run imbalance. The speed of adjustment, though, differs strongly between periods.

The ECM model appears to be well specified since it passes a list of standard diagnostic tests. The only discordant finding is the Ramsey's RESET test in the first period, which shows that there is some departure from the null of the maintained model.

Table 6: Estimated ECM relationship[a]

Variable	1871 – 1913	1919 -1939	1946 - 2010
Constant	0.004	0.002	0.013
ΔC_{t-1}	0.467***	0.420***	0.349***
ΔP_t	-120.486***	-17.274***	-54.590***
ΔP_{t-1}	64.225**		2.134
ΔP_{t-2}	-62.798**		-5.620
ΔY_t	0.274	-0.110	0.158*
ΔY_{t-1}	-0.395**		-0.066
ΔY_{t-2}	0.810**		-0.075
$\hat{u}_{t-1}$	-0.432**	-0.582***	-0.120***
$\overline{R}^2$	0.521	0.753	0.470
F-statistic	4.733***	38.051***	7.655***
Diagnostic Tests	**Value**	**Value**	**Value**
Serial correlation	2.194	0.088	0.352
Normality	4.019	1.957	0.560
Misspecification	13.326***	2.661	0.039
Stability	-1.553	-0.602	-0.521

[a]: ***, **, * Significant at 1%, 5%, and 10% level, respectively.
Serial correlation: Breusch-Godfrey test; Normality: Doornik-Hansen test;
Misspecification: Ramsey RESET test; Stability: Harvey-Collier *t*-statistics.

4.1.4 Price and income elasticities

Table 7 reports elasticity estimates at the sample mean of the relevant period. The estimated elasticities have the correct signs, *i.e.*, the demand for tobacco is negatively (positively) related to price (income) both in the short and in the long run. Second, the short-run elasticities are always smaller (in absolute terms) than the response in the long-run, as expected when dealing with the consumption of addictive goods. Third, changes in income tend to affect tobacco consumption only in the long-run (all short-run

income elasticities are numerically negligible and not significant). Indeed in the long run tobacco is a normal good and its responsiveness to income is more or less constant over time (from 0.49 to 0.46). Fourth, estimates of both short and long-run elasticities confirm that tobacco demand is inelastic to its own price and increasingly so over time (-0.48 and -0.62, respectively, in the first period, and -0.35 and -0.51, respectively, in the last period).

Table 7: Estimated demand elasticities[a]

Elasticity		1871 – 1913	1919 – 1939	1946 – 2010
Price	Short-run	-0.477 (0.118)	-0.248 (0,081)	-0.349 (0.101)
	Long-run	-0.615 (0.033)	-0.422 (0.026)	-0.505 (0.118)
Income	Short-run	0.125 (0.101)	-0,047 (0,061)	0.216 (0.121)
	Long-run	0.494 (0.044)	0.264 (0.104)	0.461 (0.062)

[a]: Values at the sample mean. Approximate asymptotic standard errors in parentheses.

For the recent period (1946-2010), our estimates appear in line with those reported in the international literature, with the prevailing values of price elasticities ranging between -0.3 and -0.5 (Cameron, 1998; Chaloupka and Warner, 2000; Gallet and List, 2003). Turning to the Italian case, previous studies find price elasticities with a median value of -0.41 and -0.75, for the short and long-run case, respectively (Escario e Molina, 2001; Stweart, 1993; Tiezzi, 2005; Gallus *et al*., 2003; Pierani e Tiezzi, 2009; Jones and Giannoni Mazzi, 1996; Rizzi, 2000). Finally, the work by Nguyen *et al*. (2012), which is close in spirit to our approach, presents estimates of the short-run price and income elasticities of cigarette demand of − 0.373 and 0.098, respectively (although the latter is not statistically significant).

Figure 3: Time path of long-run elasticities

1871 – 1913	1919 – 1939	1946 - 2010

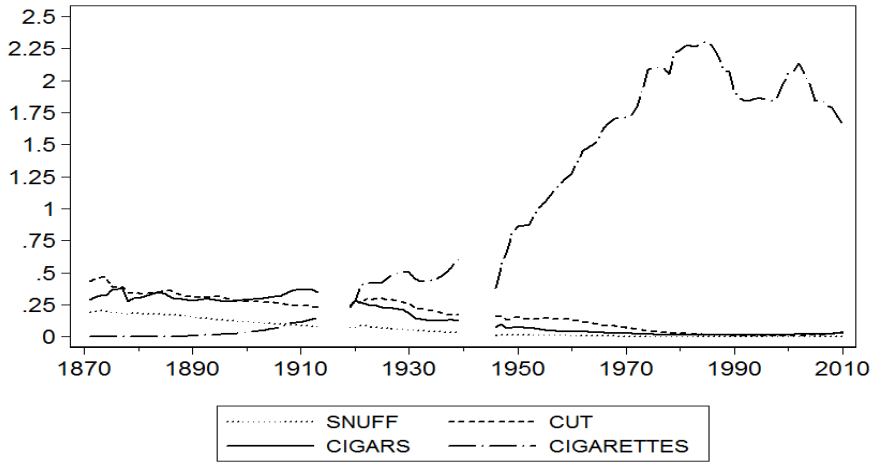
Figure 3 accounts for the temporal profile of price and income elasticities. The bold lines, always above zero, represent long-run income elasticities, while the dotted lines, always below zero, refer to long-run price elasticities.[25] Income elasticities are always within the interval [0.25, 1], suggesting that tobacco has never been considered a luxury good by Italians. Turning to price elasticities, even from a secular perspective, the long run price elasticity of tobacco has remained in the range -0.62, -0.51. This finding seems particularly surprising when one considers how radically the perspective on tobacco of both Italian policy makers and consumers has changed over time. Such a change of perspective is well represented by the inverted U shape of the price elasticity of demand in the third sub-period starting at -0.62 in 1948, reaching a threshold value of -0.19 in 1980, and going back to -0.61 by 2008. Between 1946 and 1980 smoking behavior in Italy was a status symbol associated with female emancipation and cultural evolution but not yet associated with health problems. From 1980 onwards the growing concerns about the negative health consequences of smoking might have caused the elasticity to increase again. Thus, the inverted U shaped price elasticity of demand may well reflect the transformation of tobacco from a sort of conspicuous consumption to a social stygma.

4.2 Disaggregated Analysis

[25]Estimated elasticities are always significant because confidence intervals (not shown here) never include zero. The time series of long-run elasticities, shown in Figure 3, were obtained by extrapolating, separately for each sub-periods, the estimated coefficients a_1 and a_2 of equation (1).

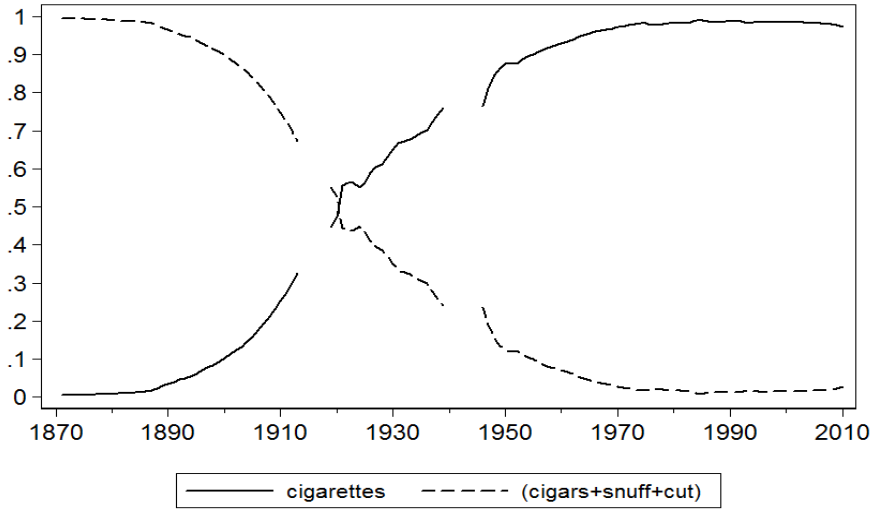
In this section we investigate patterns of per-capita expenditure on the four tobacco products. The evolution of per-capita consumption on the four tobacco products is shown in Figure 4. In the late nineteenth and early twentieth centuries the largest expenditure share was on cigars followed by cut tobacco, but their consumption gradually declined over time to around zero. Expenditure on cigarettes, however, was low in the late nineteenth century, but increased to 2.5% of total outlay (amounting to over 96% of the expenditure on tobacco products) in the most recent years.

Figure 4: Per-capita consumption of tobacco in Italy: major components, 1871-2010 (kg)



In fact, as shown by Figure 5, there has over time been an almost total replacement of the other tobacco products by cigarettes. While in 1871 snuff, cut and cigars covered 99% of tobacco expenditure, in 2010 cigarettes represented 97% of such expenditure. The historical shift in individual preferences and habits with regard to tobacco products explains these trends. The use of chewing tobacco and snuff was reduced by anti-spitting laws enacted in the late 1800s and early 1900s, intended to minimize tuberculosis and other infectious diseases (O'Connor, 2011). Kozlowski (1982) identifies as factors explaining the rise of cigarettes consumption the improvements in portable sources of fire, packaging and automated cigarette making equipment.

Figure 5: Tobacco expenditure: budget shares, 1871-2010



In recent decades, the health hazards of active and passive smoking were finally acknowledged and smoking behavior increasingly stigmatized. Since unsmoked tobacco (for example, snuff) does not imply passive smoking, it may carry less social stigma than smoking. It is therefore of particular interest to explore the substitution relationships between smoking (cigarettes, cigars and cut) and smokeless (snuff) types of tobacco.

To provide information on substitution/complementarity relationships, we compute own and cross-price elasticities for the four tobacco products from the parameters of a complete demand system, which includes a composite commodity for the remaining nondurables. The functional form chosen is the well-known Almost Ideal Demand System (AIDS, Deaton and Muellbauer, 1980). The estimated demand functions are the following budget shares:

$$w_i = \alpha_i + \sum_j c_{ij} \ln p_j + b_i \ln\left(\frac{Y}{P}\right) \qquad (4)$$

where Y is total expenditure, p_j is the price of the jth tobacco product, P is approximated by the Stone linear price index, defined as $\ln P = \sum_i w_i \ln p_i$, and the parameters c_{ij} are defined as $c_{ij}=1/2(c^*_{ij} + c^*_{ji})=c_{ji}$. A linear time trend is also included. From the demand system (4) the matrix of uncompensated

price and income elasticities can be calculated, as in Green and Alston (1990, p. 444). Along the lines of our previous aggregate analysis, we investigate here the time series properties of variables used in equation (4), i.e. budget shares in levels, prices in logarithms and a measure of per-capita income deflated by the Stone price index, in order to specify the correct dynamic specification (Attfield, 1997). Both the ADF and Phillips-Perron test statistics suggest that the unit root hypothesis cannot be rejected at the 5% level of significance for each variable included in equation (4). The next step is to test the hypothesis of cointegration using the Engle and Granger (1987) methodology. We find evidence of stationary OLS residuals and conclude that all the variables in equations (4) are I(1) and cointegrated. The estimated ECM is:

$$\Delta w_i = \xi_i \Delta w_{it-1} + \sum_j c_{ij} \Delta ln p_j + b_i \Delta ln \left(\frac{Y}{P}\right) - \lambda_i \mu_{it-1} \qquad (5)$$

where μ_{it-1} are the estimated residuals from cointegrating equations (4). The estimate of the error correction terms λ_i, are all statistically significant and have the correct signs, indicating that deviations from long-run equilibrium are corrected within the time period[26]. Table 8 shows long-run and short-run[27] uncompensated (Marshallian) price and income elasticities, along with their standard errors, derived from the estimated parameters of equations (4) and (5), respectively (using the fitted budget shares calculated at the sample mean of the investigation periods: 1871-1913, 1919-1939 and 1946-2009)[28]. We here focus on the most interesting equilibrium own and cross-price elasticities and their pattern over time (Table 8). The last column displays each commodity's income elasticity of demand. All own-price elasticities in the long are significant[29], with the correct sign, and satisfy the theoretical properties. The long-run price elasticity of cigarettes goes from -0.811 in the pre-war period to -0.253 in the latest period, pointing to

[26] Results of unit root tests and ECM estimation are available from the authors upon requests.
[27] Estimates of short-run elasticities are obtained using the same formulas as described in Green and Alston (1990) and the estimated parameters of (5), while their long-run counterparts use the estimated parameters of the cointegration equations (4).
[28] As stressed previously, the results for the second period (1919-1939) are reported for the sake of completeness. Given the low number of observations (21) any conclusion is in principle weak.

cigarettes as an increasingly price-inelastic good. This pattern is consistent both with the literature (Gallet and List, 2003) and with our findings in Section 4.1. The long-run price elasticity of cigars seems rather stable over time, going from -0.660 in the first time period to -0.676 in the most recent period. Own price elasticities for snuff and cut tobacco are not relevant in the third period because the budget shares for these products amount to almost zero. Overall these patterns are consistent with a story of gradual substitution for other tobacco products by cigarettes, driven by the secular changes in preferences described above.

Substitution relationships are particularly interesting for both their public finance and public health implications. When faced with price differentials, consumers may substitute a related product for the desired one, for example cut tobacco used for roll-your-own (RYO) cigarettes replacing packed cigarettes. In principle, public policy could manipulate such substitution behavior by setting the tax structure so as to meet policy goals, such as incentivizing smokers to adopt less hazardous forms of tobacco use. Smoked forms of tobacco other than cigarettes, such as cigars and cut tobacco used for RYO, have now been proved to impose similar health burdens (O'Connor, 2011). However, non-smoked forms of tobacco, such as snuff or chewing tobacco, do not involve passive smoking and may therefore be preferable for public health purposes.

Focusing on long-run cross-price elasticities, Table 8 shows that cigars become an increasingly strong substitute for cut tobacco over time (0.148 in the first sub-period; 0.510 in the third sub-period) and a strong complement of cigarettes in the third sub-period (-1.078) while cigarettes are a weaker complement of cigars (-0.009 in the first sub-period and -0.024 in the third sub-period), meaning that the demand for cigarettes declines much less following an increase in the price of cigars than the decline in the demand for cigars following an increase in the price of cigarettes. As expected, smokeless tobacco (snuff) in the first investigation period is a substitute for smoked tobacco (cigarettes and cut). Such a substitution relationship is symmetric, with a similar substitution relationship (snuff for cigarettes: 0.142;

cigarettes for snuff: 0.166). In the last investigation period we find instead a strong complementarity between snuff and cigarettes (-1.772). These last results have to be considered with caution given the negligible budget share of snuff tobacco. At the same time, cigarette consumption is insensitive to variations in the price of other products. The disaggregated analysis thus highlights a clear replacement of both smokeless and smoked tobacco by cigarettes over time.

Table 8: Short and long-run uncompensated price and income elasticities (at the sample mean)[a].

1871 - 1913										
ΔP / ΔQ	Snuff Tobacco		Cut Tobacco		Cigars		Cigarettes		Income	
	Short-run	Long-run	Short-run	Long-run	Short-run	Long-run	Short-run	Long-run	Short-run	Long-run
Snuff Tobacco	-0.343**	-0.460***	0.277**	0.391**	0.082	-0.066	0.077**	0.142***	-0.018	0.197
Cut Tobacco	0.108***	0.153***	-0.734**	-0.777***	0.488**	0.316**	-0.022	0.040	0.137	0.346**
Cigars	0.015	-0.013	0.23***	0.148***	-0.606***	-0.660***	-0.063	-0.009**	0.127	1.046***
Cigarettes	0.088**	0.166*	-0.070	0.118	-0.409	-0.061***	-0.773***	-0.811***	1.143***	1.009***
1919 - 1939										
	Snuff Tobacco		**Cut Tobacco**		**Cigars**		**Cigarettes**		**Income**	
	Short-run	Long-run	Short-run	Long-run	Short-run	Long-run	Short-run	Long-run	Short-run	Long-run
Snuff Tobacco	-0.223**	-0.136***	-0.008	-0.176***	0.091	0.279***	0.209	0.049***	-0.157***	-0.193
Cut Tobacco	-0.001	-0.015***	-0.005	-0.020**	-0.256	0.022***	0.098	0.006*	-0.103	-0.035
Cigars	0.006	0.001**	-0.187**	0.016***	0.075	-0.240***	-0.316*	-0.347***	0.044	0.047
Cigarettes	0.004	-0.000***	0.022	0.002**	-0.095**	-0.104***	-0.215**	-0.288***	-0.163*	-0.152
1946 - 2009										
	Snuff Tobacco		**Cut Tobacco**		**Cigars**		**Cigarettes**		**Income**	
	Short-run	Long-run	Short-run	Long-run	Short-run	Long-run	Short-run	Long-run	Short-run	Long-run
Snuff Tobacco	-0.884***	-0.850***	0.008	0.342***	0.229	0.296***	0.49	-1.722***	2.039*	1.129
Cut Tobacco	0.000	0.015***	-0.595***	-0.422***	0.051	0.385***	1.487***	-0.220***	0.729	0.282
Cigars	0.013	0.017***	0.067	0.51**	-0.536**	-0.676***	0.296	-1.078***	1.559*	1.780**
Cigarettes	0.001	- 0.002	0.022	-0.007	0.007	-0.024	-0.159	-0.253	0.718	0.309

a: ***, **, * Significant at 1%, 5%, and 10% level, respectively.

5. Implications and conclusions

This paper presents estimates of the demand for tobacco in Italy using a very long run perspective and a new dataset.

Traditionally, Italian policy makers have considered tobacco as a major source of public revenues while health related issues, in a country of illiterates such as 19th century Italy, were ignored altogether. Historical sources document explicitly the Government's urgent goal to raise the level of domestic tobacco consumption to that prevailing in other European countries. Society's opinion on tobacco consumption, in Italy as elsewhere, has however changed dramatically over time. Our statistical analysis identifies in particular in the early 1980s the period marking the reversal of the rising trend started soon after the Second World War.

In light of these considerations, it was somewhat surprising to find, throughout our secular investigation (1871-2010), a long-run price elasticity in the range -0.6, -0.5, at the sample mean, and also evidence that demand is nowadays, when growing health concerns could have triggered the opposite trend, becoming increasingly inelastic.

The result that the demand for tobacco is rigid is not surprising. Instead, an almost stable price elasticity of demand for tobacco over one and a half century is a novel result considering that prices and quantity consumed have changed dramatically over the last 150 years. This finding mimics an *iso-elastic* demand curve for which the price elasticity of demand does not vary with price and quantity.

How is this related to our results? Even though we do not specify a constant elasticity demand function, we find throughout the investigation period an estimated elasticity $\eta < 1$ which means that a price increase will always increase total expenditures. Indeed, our data describe a movement upward along the demand schedule, with decreasing per-capita consumption and increasing prices, implying a continuous rise in total expenditures on tobacco. This stylized fact coupled with an historically predominant reliance on *ad*

valorem excise taxation of tobacco compared to *specific* excise taxation, has guaranteed a continuously increasing volume of public revenues from taxation until 2003[30]. The existence between1862 and 2003 of a public monopoly of tobacco has implied that the institution setting the price and determining the structure of excise taxation was the same (the State), producing a taxation structure – in particular of cigarettes - heavily distorted in favor of *ad valorem* excise taxation (a fixed rate of the unit price) as opposed to *specific* excise taxation (a fixed amount per kilogram of product) (Manzioni *et al.,* 2011 and Liberati *et al.,* 2014 and Crespi *et al.,* 2015)[31]. When demand is iso-elastic, the optimal level of the ratio between the two types of excise taxation: *ad valorem* and *specific* (Kay and Keen, 1983: Keen, 1998) for public revenues maximization from excise taxation is:

$$\eta = -\frac{vp}{t + vp}$$

where η is the price elasticity of demand, *vp* is the rate of *ad valorem* excise taxation and *t* is the rate of *specific* excise taxation. This maximizing condition though, neglects the fact that a change in the price of cigarettes, for example, will typically affect expenditure on the other tobacco products. The strength and direction of this effect depend on both the rates at which the other goods are taxed and the magnitude and sign of cross-price effects between the goods (Keen, 1998). If the two goods under consideration are complements, as is the case for instance for Snuff and Cigarettes and for Cut tobacco and Cigarettes during 1946-2010 (see Table 8), then the larger in magnitude is the cross-price elasticity the larger the ratio of *ad valorem* taxation over total excise taxation should be to preserve constancy of the overall tax revenues from tobacco products.

A price elasticity of demand for tobacco of around -0.5, as found in our study, has allowed the government to gradually increase the share of *ad valorem* taxation over total excise taxation over time in

[30] In 2003 the management of Italian market for tobacco has passed from public monopoly to a private company: British and American Tobacco

[31] Crespi *et al.* (2015) report that, currently, in Italy the share of ad valorem excise taxation over total excise taxation is 0.87, higher than most European countries.

order to meet the optimal condition for fiscal revenues maximization. Nowadays, however, the right-hand-side term of the optimality condition is around -0.87. Since the price elasticity of demand is lower and decreasing in magnitude in the most recent years, public revenues from tobacco excise taxation are currently decreasing (Manzioni *et al.* 2011; Liberati *et al.* 2014) and their stabilization would require a reduction of *ad valorem* taxation over total excise taxation. There are other reasons that make nowadays a different structure of tobacco excise taxation in Italy desirable. Kay and Keen (1983) show that *ad valorem* taxation should be used to correct non-price aspects of market performance (such as issues of quality and product variety) while *specific* excise taxation most powerfully affects prices and thus should be used to discourage consumption. Thus the arguments that Italian tax authorities have in the most recent years used to justify high rates of taxation on tobacco – such as the desire to discourage consumption in order to decrease negative externalities – are the sort of arguments that should trigger high rates of *specific* rather than *ad valorem* taxation. Indeed, Pirttilä (1997) argues that when externalities are large enough to require a policy intervention, the optimal tax structure switches immediately to wholly *specific* excise taxation.

Our analysis also reveals an increasingly strong, and asymmetric, separability between cigarettes and other products, *i.e.* while cigarette demand is insensitive to price variations in the other tobacco products, the converse does not hold. Tobacco products other than cigarettes and cigarettes are found to be complements in the long-run. This complementarity could be good news for health policy. In addition, since smokeless forms of tobacco do not carry the same health hazards as passive smoking does, public policy could play an active role in triggering desirable substitution or complementarity relationships by introducing tax differentials for the different tobacco products.

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