How Hard Is It to Maximize Profit? Evidence from a 19th Century Italian State Monopoly

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Abstract

In this paper we study the ability of the 19th century Italian government to choose profit maximizing prices for a multiproduct monopolist. We use very detailed historical data on the tobacco consumption in 62 Italian provinces from 1871 to 1888 to estimate a differentiated product demand system. The demand conditions and the legal environment of the period made this market as close to a textbook monopoly as is practically possible. The government’s stated aim for this industry was profit maximisation: since at the time profits from tobacco were close to 10% of the revenues for the cash-strapped government, the stated aim was very likely the true one. Our empirical application uses historical price and cost data and suggests that the government was not wide off the mark: the tobacco prices were ‘not far’ from those dictated by the multiproduct monopoly formulae for profit maximisation with interdependent demand functions.

JEL Numbers: L12, L66, I18, N33
1 Introduction

In the few years after its formation in 1861, the Italian state’s revenues covered only about half of its expenditure. The government’s coffers were thus in dire needs, and revenues from the sales of tobacco products played a vital role. For example, in 1868, profits from sales of tobacco products were approximately 9% of the government’s revenues, which amounted to 750 million lire, or around one twelfth of the best estimate of that year GDP. ¹ Probably aware that its threadbare administrative network might hinder its ability to make the most of the potential from the sale of tobacco products, the Italian government chose to franchise to a private company, for a period of 15 years, the operation of the entire tobacco industry, from imports of raw material and finished products, through manufacture, down to distribution to retailers.

The government, however, retained full control of the price of all tobacco products. Moreover, the industry was kept a strict textbook monopoly, and the Finance Minister Magliani’s official reports to Parliament and the King leave no doubt that the exclusive aim of both the initial franchise and of successive negotiations with the franchisee was to maximize government net revenues: ‘if Your Majesty approves this Bill we shall expect […] yearly substantial increases of the public revenues’ (Camera 1878, p 45).² The nature of the contracts agreed with the company was such that the parties incentives with regard to price setting were perfectly aligned towards profit maximisation. However, in order to charge profit maximizing prices, you need to know them. This was not an easy task, even in the conditions of textbook monopoly created for the tobacco market. Although early French pioneers had obtained far-reaching results in the analysis of the profit maximizing (Cournot 1838) and of the welfare maximizing monopolist

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¹Revenues from taxes or profits from state monopoly on tobacco and other products with similar characteristics, such as alcohol or gaming, remain today an important source of government revenues in many countries (Cnossen 2006, Chaloupka et al 2010). As an example, in the UK in 2015, they amounted to £12 billion. By way of comparison, the direct government funding to UK universities was £5.3 billion in the same year.

²In his report to the Speaker of the House on 13 March 1879 he adds that his hard negotiating skills increased the payment the company made to the Treasury (Garbini 1997, p 420, and Camera 1878, p 42).
(Dupuit 1844), their work was not well-known (Ekelund and Hébert 1999), and thus it seems unlikely that Magliani could have been familiar with them. The rich vein of nineteenth century Italian economics did not obtain any insight on the analysis of monopoly and the inverse elasticity formula for a single product monopolist is more than half a century into the future (Robinson 1933, Lerner 1934). In addition, Italian consumers could choose among dozens of different products, whose demands were interdependent. This makes the formula much more complex (see (8) below), as the cross-substitutability among products and varieties needs to be taken fully into account to determine the profit maximizing prices. Minister Magliani, proved to be aware of this interdependence, for example when he declared in Parliament to have ‘examined each variety of tobacco, in relation not only to those similar to it, but also to those fairly different from it, to understand the effect on sales of changes in tariff of any variety’. It is however highly improbable that he could have known the actual formula; and even if he had, knowledge of the values of the cross elasticities among products is needed to apply it. There was certainly no market research organisation which could inform the decision makers in charge of tobacco prices, and so they had to make an educated guess based only on their intuitive understanding of the market and on any hard information they could lay their hands on. The aim of the paper is to assess the quality of these guesses. In other words, we ask the question: Was the government far from its declared goal to maximize profits from the sales of tobacco products?

To answer this question we proceed as follows. As a first step, we estimate a nine-equation demand system for nine tobacco products in Italy. The latter are obtained through aggregation of individual products similar in price and characteristics, which leads to a product space with three qualities each for three types of products: (i) high, 

\footnote{As one example, Pantaleoni (1889, pp 218-221) describes in words the monopolist’s incentive to restrict quantity up to the point when marginal profit is zero, but does not formalize his intuition. Nevertheless several prominent Italian economists of the late 19th century realized that large enterprises were exerting market power and exhibiting pricing behaviour not seen at the beginning of the century (Mosca, 2018).}

\footnote{Camera (1878), p 43. He seemed to believe that the cross substitutability between cigars and cut tobacco was much higher than between these varieties and snuff: this is borne out by our findings.}
(ii) medium, and (iii) low quality of (i) snuff, (ii) fine-cut tobacco, and (iii) cigars and
cigarettes. These features suggest some natural restriction for its estimation, which ap-
plies the quadratic almost ideal demand system (QAIDS) of Banks et al (1997) to a rich
panel of consumption and price data for the nine product varieties in 62 Italian
provinces for eighteen years, from 1871 to 1888. In a second step, we use the elasticities
estimated in the first step to apply the textbook formula for profit maximisation for a
multiproduct monopolist, to assess whether the actual prices were close to the values
which would be determined by the application of this formula.

The optimality of firms’ choices is often studied in the marketing literature, although
it typically addresses strategies other than prices, such as product range (Bronnenberg,
2008), or the timing of investment (Cho and Rust, 2008). It is therefore surprising that
there appear to be very few papers that explicitly study whether a given monopolist is
able to maximize profits in practice. One such paper is Asplund (2018), who uses the
national time series of chewing tobacco prices and consumption to study the behaviour
of the Swedish tobacco state monopoly supplier from 1917 to 1959.

In a nutshell, our main result is that prices were not too distant from their profit
maximizing levels. Specifically, the analysis in Section 5 shows that the prices of some
of products were not statistically significantly different from their profit maximizing
level, given the prices of all other products. It also suggests that there was no system-
atic pattern either in the level of the prices which were not approximately optimal:
some prices were ‘too high’, some ‘too low’, or in the type of products and the sign of
deviations: there did not appear to be any bias in favour or against the better-off or the
poor, nor for one type of product over any other.

The paper is organized as follows: Section 2 presents the historical background, and
sets out the theoretical framework. The data are presented in Sections 3, and the econo-
metric set-up in Section 4. Our results are collected in Section 5, and Section 6 briefly
concludes the paper.
2 The Model

2.1 The historical background

At the end of the 1860s, the Italian government handed over the entire national tobacco industry to a private company following the advise of the flag-bearer of Italian economic liberism, Francesco Ferrara, even though he viewed a state sanctioned monopoly ‘one of those absurd arrangements, which the dire needs of public finance may compel one to tolerate in the short run, until they can be buried among the historic curiosity of finance’ (Camera 1867, p 624). Under the government’s close scrutiny, the Società Anonima per la Regìa Cointeressata dei Tabacchi (Regìa hereafter), a syndicate of European financial organisations, the Duke of Galliera, the London and the Frankfurt Stern, and the Banque de Paris among them, managed all the domestic production and the distribution to retailers of all tobacco products, whether home produced or imported. Details and analysis can be found in Regìa (1886), Madsen (1916), or, in a perspective reaching almost into the 21st century, Vetritto (2005).

The original contract between the Regìa and the government, the ‘Convenzione’, enshrined into the legal system by law (Law 4544, of 24 August 1868), set the terms of the agreement, which was to last from 1869 to 1883. The contract required the Regìa to make a payment to the government in each of the fifteen years of the arrangement. This contract was renewed every few years, which leads to a natural division of the period into four subperiods. The negotiated yearly payment comprised two parts, a fixed component and a share of the profit. The first part was an annual rent, fixed at the beginning of each subperiod, intended to cover the award of the franchise and the lease of all the government owned plants and equipment to be used by the Regìa in the manufacture and the distribution of tobacco products. Article 4 of the ‘Convenzione’ established how the amount of this first part was to be determined in each of four subperiods. In the first short subperiod (1869-1870) the annual rent was set at 62% of the
gross revenues of the tobacco monopoly in 1868. In the remaining three subperiods (1871-74, 1875-78, 1879-83) the annual payment in each subperiod was equal to average yearly gross profit of the previous subperiod. Regia (1886, p 47), reports that the annual rent amounted to about 67 million lire in 1869-70, rising to 72 million lire in 1871-1874 and to just over 83 million lire in 1875-78; in the last subperiod, between 1879 and 1883, it was around 100 million lire. The second part of the payment was a share of the net annual profits obtained as the difference between the net operating profits and the annual rent. The same Article 4 specified that in the first two subperiods (1869-70 and 1871-74) the share due to the government was set at 40%. In the third and fourth subperiods (1875-78 and 1879-83) it was increased to 50%. As reported in Regia (1886, p 347), the second part of the payment due to the government increased from about 1 million lire in the starting years of the ‘Convenzione’ to reach some 8 million in 1883. This increase in revenues is reported in more detail in Figure 1. This shows the rate of return calculated as ratio between the net profit received and the fixed sum paid for the franchise by the Regia in every year. This measure is essentially the return on capital, as the administrators’ salaries are also excluded from the computation of the profit (Regia 1886, Tables on p 347 and on p 348).

It is worth noting the two sets of trends highlighted by the figure. The slightly increasing medium term trend evidenced by the linearly fitted line, and the steeper increase within each individual period bar the first, followed by a sharp drop in the first year after the re-negotiation of the contract. A possible interpretation for these is the gradual improvement in revenues and possible reduction in costs which the Regia was able to obtain in the interval when the franchise fee was fixed, the re-captured by the government at the time of the renegotiation.

The government retained the power to set the prices for all the tobacco products.

\textsuperscript{5}While on the low side in the first period, the picture suggests that, over the whole period the rate of return on investment was higher than the rate of return for investment in railways (Fenoaltea 2011), or more generally, the market rate of return (Biscaini-Cotula and Ciocca 1979). As a further yardstick, we plot the annual rate for British and Italian consols. We also note that according to liberal economist Francesco Ferrara the original 1868 agreements between the Italian Government and the Regia were too favourable to the latter (see Faucci 1975, pp 657-658). Figure 1 puts this prediction into context.
Figure 1:
Rate of return on capital for the Regia’s investment

Note: The vertical axis measures the rate of return obtained by the Regia for its investment in the tobacco franchise, in the year along the horizontal axis, with the linear fit. The different colours correspond to the four subperiods in which the Regia’s franchise is subdivided, labelled P1-P4. For comparison, we have included the market rate for British consols, the dashed line, and for Italian consols, the dotted line. Sources: Regia (1886), Fenoaltea (2011).

Given the nature of the profit sharing agreement, the payoff function of both the government and the owners of the Regia was such that both wanted to maximize the profit in each period.\(^6\) It seems therefore unlikely that there should be a conflict of interest between the parties, and in particular, it is safe to assume that the Regia would pass to the agency in charge of price setting any information which it had and which was relevant

\(^6\)From a government’s point of view, the health implications of the consumption of tobacco, or alcohol and gambling, make taxing these goods one of the least unpopular ways of raising revenues. It was considered an ‘extremely proper subject of taxation’ well before the health implications of smoking became known: this is because ‘sugar, rum and tobacco are commodities which are nowhere necessaries of life, which are become objects of almost universal consumption’ (Smith 1776, p 612).
to the setting of profit maximizing prices. When prices changed,\textsuperscript{7} sometimes all prices were uniformly increased, other times only some were affected; the timing of such changes was infrequent and fairly irregular.\textsuperscript{8} The nominal tariff for the various tobacco product types is shown in Figure 3 in Section 3 below. The franchise ended in 1884; after this date, the tobacco industry was managed by the state owned Azienda dei Tabacchi. At the end of the franchise, data continued to be collected under the management of the state owned monopoly, the Azienda dei Tabacchi, and we include in our analysis the years up to 1888, beyond which disaggregated data cease to be available. As Figures 3-5 suggest, the end of the franchise does not bring about any qualitative difference in the industry.

2.2 The product space

The legal environment in the Italian tobacco market from the 1870s described above is very close to the conditions postulated in a textbook monopoly. Supply was a fully integrated legal monopoly, from production to retail, including administration and marketing. While imports were allowed, they were also fully controlled by the Regìa; there were no meaningful substitutes for the good, and smuggling and bootlegging were negligible.\textsuperscript{9}

It was not, however, a single good monopoly. Italian tobacco consumers could choose among over fifty different products to indulge their habit.\textsuperscript{10} In practice, many

\textsuperscript{7}The main such price changes were introduced by the royal decree 2328 of 14 January 1875; by the royal decree 3541 of 9 December 1876, which also extended the national price list to sales in Sicily; by the linked royal decrees 4271 and 4272 of 2 February 1878 and 10 April 1879; and by the royal decrees 3497 and 3498 of 29 November 1885. The full set of price changes in our sample periods is listed and analysed in Ministero delle Finanze (1895), pp 477-503.

\textsuperscript{8}Thus, for example the 1875 change increased by one lira per kilogram the price of eleven products: Rapati of superior, first, second, and third quality, Caradà e Zenziglio of superior, first, second, and third quality, Trinciati of superior, first, and second quality.

\textsuperscript{9}The Regia reports (Regia 1886) that in the years 1873-1879 a total of about 90,000 kilograms of leaves and 240,000 kilograms of manufactured tobacco were seized in the country. While low seizure might simply reflect incompetence or corruption of the relevant policing agency, this amount is only approximately 0.02% of the quantity sold in the same period. Luciani (2006, pp 18ff) suggests that in the years between unification and World War I, smuggling was indeed a limited problem.

\textsuperscript{10}For example, we find that in the first period we consider, the following cigars were available to smokers up and down the country all at the price of 12.90 lire per kg: strong, light dark, fermented, Wevey
very similar products were available at identical prices and marketed with different names, often to reflect regional traditions. For the empirical analysis, therefore, it seems appropriate to categorize products that are available at the same price as a single product. We therefore combine all available products into a small set of ‘product types’. We do so in a way that blends the well-established models of horizontal (Dixit and Stiglitz, 1977 and Spence 1976, or, alternatively, Salop 1979) and vertical (Shaked and Sutton 1982 and Gabszewicz and Thisse 1979) product differentiation. The two dimensions correspond to mode of consumption and quality. In respect of the mode of consumption, we use the obvious division given by the three types of products, cut tobacco – for pipes and roll-ups –, snuff, and cigars and cigarettes. Cigarettes had a negligible quantitative importance in this period, and we include them in the cigar group, in view of the facts that most cigars sold were small in size, to be consumed in the fashion of modern day cigarettes, and that, like cigars, cigarettes were manufactured by hand-rolling. Consumption of chewing tobacco, elsewhere a relatively diffuse practice, was absent in Italy at the time. We label these three groups \(P\), \(F\), and \(C\), for ‘pipe’, ‘fiuto’, the Italian for snuff, and ‘cigar’. Along the vertical dimension, we aggregate the available brands in each product type into a threefold classification according to their quality: high, middle, and low (labeled, naturally enough, \(H\), \(M\), and \(L\)). The price range within each product group is very narrow, except for the high quality. For example the product group ‘high quality cigars’ contains domestic, Cuban, and imported varieties, each available as select, fine, superfine, exceptional. The most expensive cigars, the ‘imported ultrafine’ cost around 15 times as much as the ‘select domestic cigars’, the cheapest cigars in the same category. However, sales of the products in the upper reaches of the price range were extremely limited, indeed they were zero in most long, pressed Wevey, Swiss shape, Cavour, Nice style. A detailed description of the sources on tobacco used here is Ciccarelli (2012).

\(^{11}\)Sales of cigarettes started to increase only after the end of our panel, when the first four Bonsack rolling machines (Brandt 2007, pp 27ff) were purchased (Azienda 1892, p XXXIX). The early diffusion of cigarettes in Italy is studied in Ciccarelli and Elhorst (2018).
provinces; by far the largest component of our high quality cigars group was indeed the cheapest of them all, ‘select domestic cigar’. Thus the average price for this category is around 19.98 lire per kg in the year 1879, even though the list prices ranged in fairly regular steps from 270 lire per kg down to 18.2 lire per kg. The situation for the other ‘luxury’ product groups is similar, though less extreme.

Aggregation is simpler for products of wider consumption. Many products with different names were priced equally across the period. Using prices as the basis, we allocate ‘prima qualità’ (first quality) to the middle variety, and ‘terza qualità’ (third quality) if it exists, to the low variety. When the third quality exists, the retail price for ‘seconda qualità’ (second quality) suggests that it is nearer the middle than the lower variety, and accordingly, it is allocated to the middle quality. In most cases, only ‘first’ and ‘second quality’ were available, and so they are naturally allocated to the middle and low variety respectively.

To recap, we adopt the initials $F$, $C$, and $P$ for ‘snuff’, ‘cigars and cigarettes’, and ‘pipe or cut tobacco’, and $H$, $M$, and $L$ for ‘high’, ‘middle’, and ‘low’ quality. Thus our product space can be denoted formally as:

$$\mathcal{P} = \{FH, FM, FL, CH, CM, CL, PH, PM, PL\}. \quad (1)$$

Figure 2 depicts the trend of the profit and the revenue shares of the nine products across the years, illustrating their relative importance. Other than for cigars, revenues and profit from luxury products are negligible, and over the period the share of cigars increases steadily, with quality within the category increasing from low to normal. This does not appear to be the case for cut tobacco and snuff.

In the next two sections we lay out our assumptions regarding the technology and the consumers’ demand.
2.3 The supply side

The production side is modelled in a fairly simple manner, due both to the relatively simple nature of the technology and to the information available, which is not as detailed as on the demand side, as we explain in Section 3. We assume that the total cost of producing the entire range of tobacco products is the sum of a fixed component and a variable component, characterized, for each of the nine varieties, by constant marginal cost. So the total cost of producing the quantity vector \( \{q_i\}_{i \in \mathcal{P}} \) is

\[
K + \sum_{i \in \mathcal{P}} q_i c_i
\]

for some parameters \( K, \{c_i\}_{i \in \mathcal{P}} \). Given the available technology, this is a plausible approximation. The fixed component accounts for the administration and wholesale and retail distribution channels. These costs are common to all products, and independent of the quantities sold, and therefore they do not affect the optimal pricing policy. The
costs specific to each product are almost exclusively constituted by labour and materials, with low automation and low economies of scale or scope and limited learning by doing. All these variable costs are therefore proportional to the quantity produced. Advertising, a product specific fixed cost, was practically absent at the time, and so our assumption is very plausible that, prior to the introduction of the Bonsack machine (see footnote 11 above) the total variable costs (which in the data is reported as the ‘manufacturing cost’) is given by the cost of labour and raw materials, and hence approximately proportional to quantity.

2.4 The demand side

In standard multi-stage maximisation techniques (Deaton and Muellbauer 1980), consumers are assumed to follow a two stage decision process. In stage one, they divide their total expenditure into tobacco consumption and all non-tobacco consumption. In stage two, they allocate the tobacco expenditure determined in stage one among nine tobacco products: cut tobacco, snuff, and cigars, each available in three different qualities (high, middle, and low). Since tobacco consumption in our data covers on average 3% of total consumption expenditure we do not explicitly model stage one. We have instead tested the assumption of weak separability (Edgerton 1997) between tobacco and other goods and, having failed to reject the null of separability, we focus on stage two and estimate a conditional demand system for nine tobacco products (Pollak 1969). The resulting conditional demand functions are therefore the result of a second stage maximization process, where each demand depends on total tobacco expenditure (pre-allocated in the first stage) and on tobacco prices (Cornes 1992). To model the conditional demand functions, we assume that consumers’ preferences are such that their demand system is a linear approximation to the quadratic almost ideal demand system (QAIDS, Banks et al 1997), with a number of standard additional restrictions. The QAIDS allows for flexible income and price responses that depend on the level of total expenditure, thus providing a practical specification for demand systems such as ours,
with many interdependent commodities.

The QAIDS specification is obtained from the following indirect utility function:

$$
\ln V(p, y) = \left( \frac{B(p)}{\ln y - \ln A(p)} + G(p) \right)^{-1},
$$

(2)

where $y$ is total expenditure; $p$ is the price vector; the term $\frac{B(p)}{\ln y - \ln A(p)}$ is the inverse of the indirect utility function of a price independent generalized logarithmic (PIGLOG) demand system; $A$, $B$, and $G$ are three real valued functions of prices, with $A$ additionally being positive. Specifically, $(\ln y - \ln A(p))$ is the logarithm of real expenditure, where the deflator $\ln A(p)$ is linear homogeneous; $B(p)$ is a Cobb-Douglas price index homogeneous of degree zero in the price vector $p$, and $G(p)$ is a homogeneous of degree zero weighted average of the prices, that is $G(p) = \sum_{i \in P} \lambda_i \ln p_{it}$ with $\sum_{i \in P} \lambda_i = 0$.

The corresponding system of empirical Marshallian demand functions for goods $i \in P$, with the appropriate index to identify the year $t = 1871, ..., 1888$, expressed as expenditure shares, is obtained from (2) as:

$$
\omega_{ist} = \alpha_{i} + \sum_{j \in P} h_{ij} \omega_{jst-1} + \sum_{j \in P} \gamma_{ij} \ln p_{jt} + \beta_{i} \ln \left( \frac{y_{st}}{A(p)} \right) + \frac{\lambda_{i}}{B(p)} \left[ \ln \left( \frac{y_{st}}{A(p)} \right) \right]^{2} + \rho_{it} + \zeta_{is} + \eta_{ist}.
$$

(3)

In (3), $\rho_{i}$ captures the linear time trend associated with consumption of good $i$. The term $\zeta_{is}$ is a province fixed effect, accounting for possibly different intercepts for different groups of consumers in the empirical analysis, and $\eta_{it}$ is a random variable accounting for non-systematic errors.

The second term on the RHS of (3), $\sum_{j \in P} h_{ij} \omega_{jst-1}$, is a habit formation mechanism that captures the potential dynamic evolution of the demand functions which follows from the addictive nature of tobacco consumption. This means that past consumption,
as well as current values of prices and income also influences current demand. Thus the
intercept of the time t expenditure on product i is altered by changes in the expenditure
of the various products at time t − 1. The remaining terms in (3) are the prices, which
enter linearly, and a quadratic function of (the log of real) income.

To ensure that the demand functions (3) satisfy integrability, and so that they are
consistent with utility maximization, we require the following parametric restrictions:
for all i, j ∈ P, ∑i ai = 1, ∑i βi = ∑i γij = ∑i λi = 0 (Adding up); ∑j γij = 0 (Homogeneity);
γij = γji (Symmetry). We also impose some restrictions on the coefficients hij,
measuring addiction, in order to reduce the number of additional parameters to esti-
mate from n^2 to n (see for example Holt 1998). These restrictions are described in detail
in the Appendix.

The demand elasticities are obtained by differentiation of (3) exploiting the Cournot
and Engel restrictions (Deaton and Muellbauer 1980, p 16). The corresponding condi-
tional demand and expenditure elasticities for good i are (dropping the time index for
presentational convenience):

\[ \varepsilon_{ij} = \frac{\mu_{ij}}{w_i} - \delta_{ij}, \quad \text{for } i \neq j \]  
\[ \varepsilon_i = \frac{\mu_i}{w_i} + 1. \]  

Where δij is a Kronecker delta, δii = 1 and δij = 0 if i ≠ j:

\[ \mu_i = \beta_i + \frac{2\lambda_i}{B(p)} \left\{ \ln \left( \frac{y}{A(p)} \right) \right\}^2, \]  
\[ \mu_{ij} = \frac{\partial w_i}{\partial \ln p_j} = \gamma_{ij} - \mu_i \left( \alpha_i + \sum_j \gamma_{ij} \ln p_j \right) - \frac{\beta_j \lambda_i}{B(p)} \left\{ \ln \left( \frac{y}{A(p)} \right) \right\}^2. \]
2.5 Profit maximisation by a multi-product monopolist

The literature (see, for example Tirole 1988, p 70) has extended the well-known textbook rule for profit maximisation for a single product monopolist to the case of a multiproduct monopolist supplying goods with interdependent demand and cost functions.

In a generic set-up where \( q_i(\mathbf{p}, \cdot) \) denotes the demand function for good \( i \), \( i \in \mathcal{P} \), where \( \mathbf{p} = \{p_i\}_{i \in \mathcal{P}} \) is the vector of the prices of the products in \( \mathcal{P} \), and \( \cdot \) denotes other influences on demand, such as income, and, in the case of addictive goods such as tobacco, past consumption. Given our assumption of a constant marginal cost \( c_i > 0 \) for each variety, the monopolist’s profit maximisation problem is simply

\[
\max_{\mathbf{p} \in \mathcal{P}} \sum_{i \in \mathcal{P}} q_i(\mathbf{p}, \cdot) (p_i - c_i).
\]

Standard algebra yields the optimal price formulae:

\[
\frac{\hat{p}_i - c_i}{\hat{p}_i} = \frac{1}{\varepsilon_{ii}} - \sum_{j \in \mathcal{P} \setminus \{i\}} \left( \frac{\hat{p}_j - c_j}{q_j(\hat{\mathbf{p}}, \cdot)} \right) \frac{q_j(\hat{\mathbf{p}}, \cdot) \varepsilon_{ij}}{\hat{p}_i \varepsilon_{ii}}, \quad i \in \mathcal{P},
\]

where \( \hat{p}_i \) is the profit maximizing price for variety \( i \), and \( \varepsilon_{ii} \) and \( \varepsilon_{ij} \) are the (negative of the) own price and of the cross-price elasticities derived in (5)-(7):

\[
\varepsilon_{ii} = -\frac{\partial q_i(\hat{\mathbf{p}}, \cdot)}{\partial p_i \hat{p}_i \hat{q}_i(\hat{\mathbf{p}}, \cdot)}, \quad \varepsilon_{ij} = -\frac{\partial q_j(\hat{\mathbf{p}}, \cdot)}{\partial p_i \hat{p}_i \hat{q}_j(\hat{\mathbf{p}}, \cdot)}.
\]

(8) requires that this should be equal to the inverse elasticity (the first term on the RHS of (8)), as in the standard single good case, but here adjusted by the effect of the price change on the demand for the other goods: this is given by the ratio between the change in the profit generated by that good, the numerator in the second term in (8), and the revenues of good \( i \), added up over all the goods other than \( i \). Tirole (1988, p 70) discusses in detail the intuition for the case of substitute and complementary goods.
3 Data

3.1 Tobacco products

Our data for consumption of tobacco in the period comes from a panel data on annual sales of several dozens of tobacco products from 1871 to 1888 in the 62 provinces of continental Italy and Sardinia. Data on sales for the years 1869 and 1870 are inadequate and therefore they are not included in our dataset. In addition, the franchise was extended to Sicily only in 1877, and disaggregated consumption data for Sicily prior to that date (if it ever existed) has not been preserved. Therefore we exclude the data for the seven Sicilian provinces from our analysis. Since the contractual terms between the Regia and the government established precisely the payments as a function of the operating profits, the contract also required the Regia to keep very accurate accounting of revenues and costs. Provincial sales, in weight and in values, are recorded for each separate product. Record keeping continued with this level of accuracy for four years beyond the end of the franchise in 1883, but became much less detailed after 1888.\(^\text{12}\) We view each province as a representative consumer. This has some justification in view of the constraint that prices are uniform across all the provinces.

The data is obtained from the original annual\(^\text{13}\) budget reports, which are public. These include, for every province, every year, and everyone of the fifty or so different products, the sales to retailers, in kilograms, the revenues, and of course the prices, which are set by a royal decree and are uniform across the country. As we explain above, we group the several dozens different products in three product types and in three quality levels.

\(^{12}\)The end of the franchise coincided with a change in the government’s financial year. Specifically, data for the years 1871 to 1883 records deliveries from January to December; subsequently there is financial data for the January-June semester of 1884, from then on, the reporting period shifts to July-June. We split in half the values of each year after 1884, and constructed the value for the calendar year by adding up the two halves obtained from two subsequent reported years.

\(^{13}\)For example Regia (1878), and Azienda (1886) covers respectively the financial years 1877 and that ending on 30 June 1885.
3.2 Marginal cost

The aim of our paper is to assess if the prices chosen by the government were close to those that would be determined by the optimal pricing rule (8). We argue above that it is reasonable to assume constant marginal cost for each of the products.

Historical data provide us with two observations of the cost of each product. Camera (1879) for 1877, and Azienda (1886) for 1884 give a detailed breakdown of the cost of tobacco leaves and other raw material ingredients such as perfumes and packaging for each product. Raw material costs account for approximately half of all costs (Regìa 1886). We attribute all other costs to each product in proportion of the cost of raw materials for that product. It seems reasonable to assume higher labour costs for products using more expensive raw materials. From these observations we interpolate to obtain the cost observation in each year for each of the nine products group. We do so positing that cost is constant prior to 1877, and equal to the cost level of that year, and conversely, that cost is constant later than 1884, and again equal to the 1884 level. Between those two dates, we take a linear interpolation.

3.3 The price index

The nominal price for product group $i \in \mathcal{P}$, in province $a$, in year $t$ is calculated simply by dividing the value, in lire, of the total sales of the products in group $i$ by the total quantity sold in province $a$ in year $t$, $i \in \mathcal{P}$, $a = 1, \ldots, 62$, $t = 1871, \ldots, 1888$. To the extent that the composition of the consumption basket was different in the various provinces, there could be some variation in the nominal price from province to province, even though each individual product was sold at the same list price. Because some products with extremely high unit prices are included in the luxury products groups, this source of variation is more relevant for the luxury varieties, as shown by their higher standard deviation of the nominal price illustrated in Table 1, which reports the summary statistics for the geographical variability, measured by the standard
Table 1:
Cross-sectional dispersion of the provincial price: 1871-1888

<table>
<thead>
<tr>
<th>Nominal Prices</th>
<th>mean</th>
<th>st dev</th>
<th>min</th>
<th>max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Luxury Snuff: FH</td>
<td>0.521</td>
<td>0.622</td>
<td>0.000</td>
<td>1.320</td>
</tr>
<tr>
<td>Normal Snuff: FM</td>
<td>0.003</td>
<td>0.012</td>
<td>0.000</td>
<td>0.051</td>
</tr>
<tr>
<td>Low quality Snuff: FL</td>
<td>0.224</td>
<td>0.149</td>
<td>0.127</td>
<td>0.496</td>
</tr>
<tr>
<td>Luxury Cut-Tobacco: PH</td>
<td>0.689</td>
<td>0.227</td>
<td>0.205</td>
<td>0.994</td>
</tr>
<tr>
<td>Normal Cut-Tobacco: PM</td>
<td>0.008</td>
<td>0.027</td>
<td>0.000</td>
<td>0.110</td>
</tr>
<tr>
<td>Low quality Cut-Tobacco: PL</td>
<td>0.004</td>
<td>0.015</td>
<td>0.000</td>
<td>0.063</td>
</tr>
<tr>
<td>Luxury Cigars: SH</td>
<td>2.115</td>
<td>0.894</td>
<td>1.039</td>
<td>3.509</td>
</tr>
<tr>
<td>Normal Cigars: SM</td>
<td>0.017</td>
<td>0.046</td>
<td>0.000</td>
<td>0.190</td>
</tr>
<tr>
<td>Low quality Cigars: SL</td>
<td>0.438</td>
<td>0.350</td>
<td>0.091</td>
<td>1.255</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Real Prices</th>
<th>mean</th>
<th>st dev</th>
<th>min</th>
<th>max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Luxury Snuff: FH</td>
<td>1.513</td>
<td>0.254</td>
<td>1.102</td>
<td>1.815</td>
</tr>
<tr>
<td>Normal Snuff: FM</td>
<td>0.771</td>
<td>0.148</td>
<td>0.571</td>
<td>1.075</td>
</tr>
<tr>
<td>Low quality Snuff: FL</td>
<td>0.326</td>
<td>0.147</td>
<td>0.194</td>
<td>0.607</td>
</tr>
<tr>
<td>Luxury Cut-Tobacco: PH</td>
<td>1.233</td>
<td>0.437</td>
<td>0.721</td>
<td>2.282</td>
</tr>
<tr>
<td>Normal Cut-Tobacco: PM</td>
<td>0.797</td>
<td>0.205</td>
<td>0.571</td>
<td>1.288</td>
</tr>
<tr>
<td>Low quality Cut-Tobacco: PL</td>
<td>0.240</td>
<td>0.033</td>
<td>0.153</td>
<td>0.298</td>
</tr>
<tr>
<td>Luxury Cigars: SH</td>
<td>2.137</td>
<td>0.346</td>
<td>1.632</td>
<td>2.674</td>
</tr>
<tr>
<td>Normal Cigars: SM</td>
<td>1.357</td>
<td>0.334</td>
<td>1.023</td>
<td>2.194</td>
</tr>
<tr>
<td>Low quality Cigars: SL</td>
<td>0.727</td>
<td>0.338</td>
<td>0.350</td>
<td>1.582</td>
</tr>
</tbody>
</table>

Note: The table reports the summary statistics for the standard deviation of the nominal (upper part) and real (lower part) prices across the 62 provinces in a given year. A standard deviation of 0 for a year indicates that prices were constant across provinces in that year. Given that the retail price of every product was constant across the nation, a difference in nominal prices in different provinces (and hence a non-zero standard deviation) would follow from different proportions of products with different retail prices which we attributed to the same product group. In the real part, different nominal prices are compounded by different cost of living indices in different provinces.

deviation, of the prices of the products in each year. The very expensive products were, however, a tiny proportion of the total sales, and excluding them does not change the empirical results obtained.

14To consider a simplified example, suppose that the product group SH, luxury cigars, included ‘exceptional cigars of first quality’ and ‘common cigars of second quality’, which had nominal prices of 216 and 63 lire respectively in year 1875. If in Udine the quantities sold were 1.2 kg and 33 kg respectively, and in Turin they were 29.3 kg and 407.8 kg, the nominal price of the product group SH is 68.36 lire in Udine and 73.25 lire in Turin, and so the standard deviation is 2.44 > 0. The group FM (normal snuff) also included different varieties, ‘second quality rapato’, and ‘erbasanta’, but in the year 1875 these products have the same nominal price of 7.2 lire. Clearly, the standard deviation of the nominal price of product group FM across provinces in 1875 is 0.
If the above method of calculating the nominal price is relatively uncontroversial, once the allocation of products to group is accepted, care is required to determine the real price of the various products. The reason is that the different qualities were consumed everywhere by consumers of different income classes, and they were affected differently by changes in the prices, depending on changes in the relative prices of the goods which constituted the bulk of their purchases. The pattern of consumption among the various social groups was very different indeed, with a large proportion of the population consuming essentially only subsistence goods. For this reason, we turn nominal prices into real prices using different price indices for the three quality levels.

It has been forcefully argued (Fenoaltea 2011), that the basket used to calculate the official cost of living index provided by ISTAT (1958), which does not include the price of inferior grains, should be considered a price index only ‘representative for the better off’ (Fenoaltea 2011, p 127). For this reason, we use this index to deflate only the prices of the highest qualities in the three product groups.

While spatial differences in standards of living prices are unlikely to influence tobacco consumption for the better-off, they may do so for middle income and even more for low income smokers. Thus, for middle and low qualities, we adjust the prices with an index that captures provincial, as well as annual, variation in prices. Specifically, we adjust the price of the low quality tobacco products using an index of the price of wheat. As explained in Vecchi (2017), cereals, and wheat in particular, represented an important component of the diet of the consumers with the lowest incomes, those therefore who were more likely to purchase the lower qualities. We construct an index from data on the price of wheat in 70 local markets, uniformly distributed over the national territory\textsuperscript{15} and adjust the nominal price of the lowest qualities in the three product groups with this index. Transport cost is an important component of the cost of wheat, and, for this reason, its price exhibited considerable spatial variation across the

\textsuperscript{15}The data were kindly provided by Giovanni Federico and are described in Federico (2007).
national territory. When transport costs fell, the price of wheat dropped considerably in our sample period (O’Rourke 1997). It is therefore particularly important to account for this temporal variation in the purchasing power of low income consumers. The consumers in the middle of the income distribution, those for whom the price of intermediate quality products were probably the most relevant, were more likely to be affected by changes in the price of housing. We do not have provincial time series for property prices, and we proxy this with the registry tax, a tax levied on estate transactions, and thus positively correlated with real estate sale price, which in turn are likely to affect rents.\textsuperscript{16}

To sum up, we calculate the real price by dividing the nominal price by the cost of living index appropriate for the three different quality levels of the three product types. These indices are the official national price index (provided by the Italian national institute of statistics ISTAT 1958) for the luxury products, the provincial cost of housing, proxied by the estate registration tax take, for the intermediate qualities, and the provincial wheat price index for the lowest qualities. Adjusting the nominal prices using these three indices ensures that the prices of each product group are comparable across time for each product and also across products for each of the three quality levels. There is no obvious way to ensure comparability of the different products across the three quality levels. In the results we have reported here, we have normalized the three indices in such a way that they have the same weighted mean (with population as weights) and the same standard deviation across provinces and years. Different normalisations yield similar results.

Figure 3 shows the time trend of the nine prices. In each of the nine panels, the vertical axis measures a price index, adjusted as explained above to make it comparable across products (note that the vertical scale differs among the products), and the dark red line is the average value of this index, with the $+2$ and $-2$ standard deviation range.

\textsuperscript{16}A detailed description of the historical sources on tax data can be found in Ciccarelli and De Fraja (2014), p 168.
Figure 3: 
Time trend of real price, nominal tobacco tariffs and marginal costs

Note: Each panel shows the real price, adjusted using the index of the price of wheat, that of the registry tax, and the general price index as explained in the text. The mean price is the red solid line, and the grey band includes the range from two standard deviations above to two standard deviation below the mean prices. The green line is the nominal tariff, and the orange line the marginal cost, interpolated from the available observations as explained in the text.

shaded in grey. The dotted green line is the unadjusted government tariff, measured in nominal lire, and constant across the national territory, and the orange dotted line is the marginal cost for the various products, extrapolated as we explain in Section 3.2 from the two observations we have.

Finally, Figure 4 reports the per capita consumption of the nine products, in kg per
**Figure 4:**
Time trend of per capita consumption for the nine products

![Graph showing time trend of per capita consumption for nine tobacco products.](image)

**Note:** Each panel shows the per capita consumption, in kg per year, of the nine tobacco products. The solid line is the mean quantity, and the grey band includes the range from the eightieth to the twentieth province percentile.

year. The grey bands include, to provide an idea of the spatial variation of consumption, the range between the eightieth and the twentieth province percentile.

### 3.4 Other data

Consumption data is measured on a per capita basis; data on the population for each province is derived from the population census (which took place in 1871, 1881, and 1901). We interpolate linearly to infer the population in the remaining years. We use
data for the population over 15, though little changes in any estimation if we use the entire population instead. This comes as no surprise, once it is noted that the correlation with the total population is 0.999.

An important determinant of the demand for tobacco, and indeed for any other consumption good, is income. While yearly GDP for the relevant geographical areas is an acceptable proxy for the disposable income of the representative consumer of that geographical area, historical data or statistical reconstructions on yearly provincial GDP data do not exist. Ciccarelli and De Fraja (2014, pp 154-155) argue at length that an acceptable proxy for annual GDP by province is provided by the sum of the tax receipts in the three main components of the broad category defined business tax (*Tasse sugli Affari*). Without going into all the details of their paper, the state budget had three main categories of taxation, which can broadly be translated as ‘direct taxes’, ‘consumption taxes’, and ‘business taxes’. Direct tax was essentially a wealth tax, and therefore had a very narrow basis, the number of taxpayers limited to a subset of the wealthiest households, making it unsuitable as a proxy of GDP. Consumption taxes were likely skewed in the opposite direction: they were excise taxes, levied on specific goods, such as grappa, beer, chicory, sugar, gunpowder, and – to deep resentment among the poor – flour. For these reasons, we only consider business taxes, and, in this broad category, only some subcategories. We include taxes on transfers of property, stocks and bonds, and substantial real assets, including lets, mortgages, which required transcription onto the Land Registry; we also include all fees on such disparate items as court acts and petitions, IOUs, cheques, train, tram and theatre tickets, playing cards, insurance and so on. Thus we form a fairly broad and diverse basis, and thus changes in its level are likely to reflect changes in disposable income across income levels, as well as time and space.\(^{17}\) At the end of the period considered here, these taxes accounted for approximately 15% of total government taxes, and about 1% of GDP. Ciccarelli De Fraja (2014)

\(^{17}\) As noted by Boria (2008). Mortara (1913) also uses *Tasse sugli Affari* to construct his measure of regional development index. We cannot use Mortara’s index for this paper, as it does not include provincial data.
argue therefore that the nominal figure should be multiplied by 100, and that this yields national and regional values consistent with other estimates. Special circumstances affecting only some provinces, such as the presence of a major port, are accounted for with the inclusion of province fixed effects. Indirect support for the use of business taxes as proxy for disposable income comes from the computation of correlation with the available estimation of the 19th century Italian GDP. This can be done from two viewpoints. The first is to compute the correlation between the national GDP estimated by Fenoaltea (2005) and the total take of the business tax in the period 1871-1888: this correlation is 0.84. The second viewpoint is to use Brunetti et al’s (2011, p 428) estimates of GDP for the 16 Italian regions for the years 1871 and 1891; the latter is just out of our sample. Adding up the business tax collected in the provinces that make up each of these 16 regions we obtained a correlation of 0.9 for 1871 and 0.84 for 1891. The correlation remains very good, at 0.92, for 1911.

We end this section with an important observation. Tobacco can be stored for some time, certainly a lot longer than a few days. Rational consumers could therefore be tempted to purchase some weeks’ worth of consumption ahead of a price increase in order to delay paying the higher prices. As we have noted above, Minister Magliani was a shrewd man, and we were not at all surprised to find that he was well aware of this possibility. He circumvented it simply by introducing all the main price changes with a Regio Decreto, a royal decree: this was a legislative act which came into force immediately, thus avoiding the need of public Parliamentary discussion prior to the increase. This tactic was precisely designed to catch the public unawares. In the words of Magliani himself: ‘consumers, with advanced warning of a price increase, would detract enormous amounts of tobacco from the new tariff’ (Camera 1878, p 2).
4 Testing for Optimal Pricing: Econometric Specification

We assume that the government knows the demand function for the products it sells, and it chooses the prices, which it is free to select at will, provided they are constant across the country, in order to maximize profits. To test whether the government was indeed successful in setting the profit maximizing prices, we proceed in two steps. The first consists of estimating the parameters of the demand system in (3) and of obtaining the derived elasticities. In the second step, we apply (8), the formula which determines the prices set by a profit maximizing multi-product monopolist.

So we begin with the estimation of the demand functions. Empirically, the concavity of the expenditure function, which implies a negative semidefinite Slutsky matrix, is often violated. While adding-up, symmetry and homogeneity can be imposed via the functional form, and therefore hold globally, negative semidefiniteness of the Slutsky matrix is not explicitly built into the model, and need to be imposed locally. We did so using the semiflexible technique. While preserving a degree of flexibility, the demand system this yields is more parsimonious than standard ones, and satisfies locally the curvature property of the expenditure function (Diewert and Wales 1988; Moschini 1999; Ryan and Wales 1999). In this case, we have a system of nine equations, whose stochastic version can be thought of as a correlated system (Zellner 1962) which we can estimate with maximum likelihood techniques, with standard errors clustered at the province level. We report in Table 2 below some of the estimated parameters. From these parameters we compute the matrix of conditional uncompensated own and cross-price elasticities for the nine products in each year of our period of investigation according to equation (4). These are reported in the last two columns of Table 2.

The second step of our analysis is the determination of the ‘closeness’ of the actual prices to the profit-maximizing ones. We do so indirectly, by asking the closely related question of whether, given the estimated demand functions and the known cost parameters, plugging the actual prices into (8), we obtain a value that is not statistically
significantly different from 0. Unlike for prices, quantities demanded, and cost parameters, \( p_i, D_i(p, \cdot) \), and \( c_i \), which are observed, the elasticities are obtained from the estimation of the demand system, and thus are within a confidence interval. Clearly, relation (8) may turn up to be statistically significantly different from 0 for one or both of two order of reasons: the government educated guess of the shape of the demand system was wrong, or the intuitive application of (8) was wrong. Recall that at the time, methods of demand estimation and the theoretical analysis leading to (8) were decades into the future. To sum up, our test of monopoly pricing is a test of the following null hypothesis for each of the nine product groups in each of the 18 years.

\[
\frac{p_i - c_i}{p_i} - \frac{1}{\hat{\varepsilon}_{ii}} + \sum_{j \in \mathcal{P} \setminus \{i\}} \frac{(p_j - c_j) q_j \hat{\varepsilon}_{ij}}{q_i p_i \hat{\varepsilon}_{ii}} = 0, \quad i \in \mathcal{P}, \tag{9}
\]

In (9), \( p_i \) is the official tariff price of good \( i \), and \( q_i \) is the observed quantity sold of good \( i \), and \( c_i \) is the marginal cost of product \( i \) as determined in Section 3.2. \( \hat{\varepsilon}_{ii} \) and \( \hat{\varepsilon}_{ij} \) are the estimated own and cross price elasticities obtained from the estimation of the demand system (3).

If (9) is violated for product \( i \), then the price of product \( i \), keeping into account the prices of all other goods, is not set at the profit maximizing level. Formally, rejection of the null hypothesis that the LHS of (9) is 0 for good \( i \) is tantamount to rejecting that the price of good \( i \) is set at the profit maximizing level. The plausibility of this argument depends on the accuracy with which we estimate the cross price elasticities involved; more accurate estimates of elasticity tightens the confidence intervals of the LHS, and therefore decrease the likelihood of type-2 errors. We estimate equation (9) for each year of our investigation period, keeping constant over time the coefficients of income shares estimated in (3). To compute standard errors and 95% confidence intervals, we use bootstrapping with 500 replications of the parameter vectors.
Table 2:
Estimated and Computed Coefficients

<table>
<thead>
<tr>
<th></th>
<th>$\beta_i$</th>
<th>$\lambda_i$</th>
<th>$\gamma_{ii}$</th>
<th>$\epsilon_i$</th>
<th>$\epsilon_{ii}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Luxury</td>
<td>.00744**</td>
<td>.0117</td>
<td>-.00341</td>
<td>1.972***</td>
<td>-1.438</td>
</tr>
<tr>
<td>Snuff: FH</td>
<td>(.00357)</td>
<td>(.00758)</td>
<td>(.00333)</td>
<td>(.464)</td>
<td>(.428)</td>
</tr>
<tr>
<td>Normal</td>
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<td>.102**</td>
<td>-.0199***</td>
<td>1.263***</td>
<td>-1.255***</td>
</tr>
<tr>
<td>Snuff: FM</td>
<td>(.0119)</td>
<td>(.0451)</td>
<td>(.00724)</td>
<td>(.153)</td>
<td>(.0927)</td>
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<tr>
<td>Low quality</td>
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<td>-1.001</td>
</tr>
<tr>
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<td>(.0356)</td>
<td>(.00101)</td>
<td>(.101)</td>
<td>(.0132)</td>
</tr>
<tr>
<td>Luxury</td>
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<td>-.0149</td>
<td>-.0211***</td>
<td>.194</td>
<td>-4.899***</td>
</tr>
<tr>
<td>Cut-Tobacco: PH</td>
<td>(.00212)</td>
<td>(.00919)</td>
<td>(.00697)</td>
<td>(.478)</td>
<td>(1.579)</td>
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<tr>
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<td>-.283***</td>
<td>.947***</td>
<td>-4.14***</td>
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<tr>
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<td>(.0517)</td>
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<tr>
<td>Low quality</td>
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<td>.00925</td>
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<td>1.126***</td>
<td>-2.8***</td>
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<tr>
<td>Cut-Tobacco: PL</td>
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<td>(.11)</td>
<td>(.0433)</td>
<td>(.116)</td>
<td>(.177)</td>
</tr>
<tr>
<td>Luxury</td>
<td>-.0903***</td>
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<td>-.0999***</td>
<td>-4.37**</td>
<td>-2.567***</td>
</tr>
<tr>
<td>Cigars: SH</td>
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<td>(.0202)</td>
<td>(.192)</td>
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<tr>
<td>Normal</td>
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<td>-.201</td>
<td>-.0535*</td>
<td>-.202</td>
<td>-1.234**</td>
</tr>
<tr>
<td>Cigars: SM</td>
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<td>(.0324)</td>
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<td>(.139)</td>
</tr>
<tr>
<td>Low quality</td>
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<td>.163</td>
<td>-.269***</td>
<td>2.57***</td>
<td>-2.337***</td>
</tr>
<tr>
<td>Cigars: SL</td>
<td>(.0336)</td>
<td>(.191)</td>
<td>(.0531)</td>
<td>(.166)</td>
<td>(.263)</td>
</tr>
</tbody>
</table>

Note: *** $p \leq 0.01$, ** $p \leq 0.05$, * $p \leq 0.1$. Estimated coefficients: the first three columns are the coefficients obtained from estimation of equation (3). The last two columns are the income and own-price elasticities computed from the data and the estimated coefficients from formulae (5) and (4), respectively. For each row the standard error is reported in brackets below the coefficient. The significance stars for the last column, indicate the $p$-values for the null hypothesis that the own elasticity parameter is less than $-1$, ensuring an elastic demand. All the coefficients in this column are also statistically different from 0.

5 Results

Table 2 reports the estimation of the demand system. From the table, we can see that the effect of the price of good $i$ on the expenditure share of the same good $i$, the coefficient $\gamma_{ii}$, is negative, as it should, for all nine goods. The sign of the demand elasticities $\epsilon_{ii}$, calculated from (4) at the sample mean by the last column of the matrix, are all negative and statistically significant: they are also larger than 1 in absolute value, statistically significantly in all but two cases. Although for a multiproduct monopolist is not
a necessary condition for optimality, given that the relevant benchmark is the aggregate profit, it is encouraging to see the monopolist on the elastic part of its demand curves. Encouragingly, all the own habit formation coefficients, $h_{ii}$, are statistically significant, with the expected sign and rather large in magnitude suggesting that habits are an important determinant of the demand for tobacco products. $\beta_i$ and $\lambda_i$ are the income and income square coefficients of the expenditure share of good $i$. These enter the computation of the income elasticity at the sample mean $\varepsilon_i$ (see (5)). As the penultimate column in Table 2 shows, this is positive and significant for all goods, except luxury cigars (negative) and normal quality cigars (not significantly different from zero): while in the middle of the nineteenth century one does expect tobacco to be a normal good, the coefficient for luxury cigars suggests an inferior good, as tobacco is nowadays in most high-income countries (Colman and Remler 2008).\textsuperscript{18}

We can now present our main results. This involves checking whether the $9 \times 18$ values we obtained for the LHS of (9), one per product per year, are significantly different from zero. It is best to do so with the pictures in Figure 5. As in Figures 3 and 4, each of the nine diagrams represents one product, and the horizontal axis measures time, spanning the period 1871-1888 we study.

The vertical axis in each diagram reports the computed LHS of equation (9). The solid red line in each diagram is the computed value of the LHS, and the grey band contains the 95% confidence interval.\textsuperscript{19} The black horizontal line is drawn at zero, the ‘target’ value of expression (9): note that neither the scale on the vertical axis nor the position of the black horizontal line are the same in the nine diagrams. In other words,

\textsuperscript{18}Though some evidence casts doubt on this, (Kenkel et al 2014), especially for low income groups within a country. Aside from the possibility that the nineteenth century Italian smokers followed the pattern of viewing cigars as a normal good if they had low income and as an inferior good if they had higher income, an alternative explanation for the negative coefficients for the income elasticity could be a substitution of quantity for quality: rich consumers switched to the top category of luxury cigars, and smoked many fewer of them.

\textsuperscript{19}Standard errors are obtained using bootstrapping, by drawing 500 simulated parameter vectors. This results in asymmetric confidence intervals for non linear functions; the asymmetry can be quite pronounced for luxury snuff and luxury cut-tobacco, which were sold in extremely small quantities, see Figure 2. These non-linear functions are also varying over time.
Figure 5:
Time trend of the deviation from monopoly price.

Note: Each panel, the red line shows the difference between the RHS and the LHS of (8), that is the difference between the optimal and the actual mark-up, calculated as explained in the text. A positive value indicates that the price is “too high”, that is that the actual mark up exceeds the optimal mark-up. The grey band is the 95% confidence interval, obtained by bootstrapping.

Figure 5 depicts, for each product, the marginal profit in each year. The marginal profit is calculated taking into account all the effects of a change in the price of a given product, not just the change in the difference between the total revenues for that product and cost.
of supplying the total quantity sold, but accounting also for the changes in the quantity of substitute and complementary products as well.

When the LHS is positive for good \( i \), then the price exceeds its profit maximizing level, and vice versa. Visual inspection of the nine diagrams suggests that, overall, in many years and for many products, we cannot reject the null that the LHS of (9) was significantly different from zero: loosely speaking, prices were not far from their profit maximizing level. There appears to be no regular pattern in the deviations: some prices were a bit too high (such as the low quality and the normal cut tobacco and the low quality cigars), some a bit too low (normal cigars and low quality snuff). The price for luxury snuff and luxury cigars is not significantly different from the optimum throughout the period, though we note that the revenues from these products, especially the former, are very small. The prices for normal snuff and luxury cut tobacco appear to be too high in the first part of the period we study, and too low later on. It may be also worth noting how the nominal mark-up (the distance between the orange and the green line in Figure 3) varied considerably in time for each product and among products: this indicates that the ministry was not simply following a constant mark-up rule, either overall or even product by product, but seemed to be increasing prices only for some goods, and those selective price changes did not bring about corresponding changes in the value of the LHS of (9), suggesting that, consciously or unconsciously, prices were increased more for the goods were demand was also increasing most. A possible broad interpretation of our results is that the management of the private franchise and the civil servants who chose the new prices displayed an intuitive understanding of their market, even in a historical context where sophisticated data analysis was unavailable and the complex formulae for multiproduct profit maximizing prices had not yet been derived.

There does not appear to be any tendency for prices to converge to their profit maximizing level overtime: that is, Minister Magliani and his staff did not appear to learn
by doing. This may be explained, at least in part, by the limited opportunity for experimenta-
tion, which in turn could be due to the low frequency of price changes, as doing so required a legislative intervention as well as national coordination.

6 Concluding Remarks

We study in this paper a simple question. Did the Italian post-unification government achieve its declared aim to maximize the profits generated by the tobacco monopoly? On the production side, it seems very plausible to assume that marginal cost is constant, given the state of the technology at the time. The government’s job was the selection of the price vector, with the restriction of uniform prices across the national territory. This was an extremely complex problem, because of the very large number of products under the government’s control, the widely varied pattern of demand across provinces, and the requirement of uniform prices across the country. The fifty or so products can be aggregated into nine groups which follow a natural pattern of vertical and horizontal product differentiation: three product types (cut-tobacco, snuff, and cigars) each available in three qualities. The interdependence in demand creates a highly complex nine variable maximisation problem. While the government minister responsible for the overall management of the industry was aware of the interdepen-
dence of demand for the nine products, and while we are unable to confirm conclusively that the aim of profit maximisation was achieved, it would seem that prices were not ‘too far’ from the profit maximizing ones.

While firms owned by the state, or otherwise controlled by it, for example through regulation, are not usually required to maximize profit, our analysis may be relevant to the study of related areas of government intervention: for example the optimality of taxes on tobacco, gaming, or alcoholic drinks. The latter was studied recently by Miravete et al (2018), in an environment, like our own, where the decision maker is unable or unwilling to charge different prices in different areas.
Supplementary material

Supplementary material is available on the OUP website. These are the dataset used in estimation and the replication files to replicate the quantitative analysis.

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Appendix

In this appendix, we derive formally the restriction on the coefficients of the ‘addiction’ matrix $H$.

With no restrictions on their matrix, the $h_{ij}$ coefficients of the dynamic effects in equation (3) are not identified (Anderson and Blundell, 1982). Edgerton (1997) and Rickertsen (1998) suggest imposing the restriction $\sum_i h_{ij} = \sum_j h_{ij} = 0$. This implies however the estimation of $(n - 1)^2$ additional parameters. We here adopt a more parsimonious dynamic structure, adopted by De Boer and Harkema (1986), Moschini and Moro (1994) and Holt (1998) among others, involving the estimation of only $n$ adjustment parameters. With this parsimonious dynamic structure, the matrix $H$ of adjustment parameters $h_{ij}$ is $H = G - \frac{gg'}{rg}$ where

$$G = \begin{pmatrix} g_1 & 0 & \ldots & 0 \\ 0 & g_2 & \ldots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \ldots & g_n \end{pmatrix}, \quad \text{and} \quad g = \begin{pmatrix} g_1 \\ \vdots \\ \vdots \\ g_n \end{pmatrix}.$$

The $H$ matrix is symmetric: $h_{ij} = h_{ji}$, singular: $\sum_i h_{ij} = \sum_j h_{ij} = 0$, and with elements:

$$h_{ij} = g_i \delta_{ij} - \frac{g_i g_j}{\sum_i g_i}, \quad (A1)$$

where $\delta_{ij} = 1$ if $j = i$; and $\delta_{ij} = 0$ if $j \neq i$. The $\alpha_{it}$ parameters in equation (3) are modified accordingly:

$$\alpha_{it} = \alpha_i^* + \sum_{j=1}^{n-1} \left( g_i \delta_{ij} - \frac{g_i (g_j - g_n)}{\sum_i g_i} \right) w_{jt-1}. \quad (A2)$$

with $\alpha_i^* = \alpha_i + h_{in}$ and $\sum_i \alpha_i^* = 1.$