Did the Swedish Tobacco Monopoly Set Monopoly Prices?*

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Abstract

Do firms set profit maximizing prices? An affirmative answer implies that firms both aims at, and are able to, set prices to maximize profits. Despite the question's importance it is difficult to devise an empirical test since it requires not only knowledge about firms' costs and demand conditions but also the nature of the strategic interaction in markets. This paper sidesteps the problem of strategic interaction by providing a detailed case study of a monopolist's pricing decisions. The idea is to examine pricing behaviour of a monopolist facing a dynamic demand where current sales influence future demand. Empirically, I estimate an Euler equation implied by profit maximization on data from the Swedish Tobacco Monopoly's sales of moist snuff (an addictive tobacco product) over the period 1917-1959. It is found that the monopolist's prices are well below those that would maximize the expected net present value of profits. I discuss the extent to which the evidence from STM is consistent with implications from the maximization of some alternative objective functions.

1 Introduction

Do firms set profit maximizing prices? An affirmative answer implies that a) firms' objective is to maximize profits, and b) firms are able to select the prices that do. The attack on these two preconditions began in earnest following two studies in the 1930s. Berle and Means (1932) pointed to the fact that many firms were controlled by managers rather than owners, and Hall and Hitch (1939) showed that a majority of surveyed firms set their prices according to simple rules of thumb with little or no reference to demand conditions or marginal costs. A heated debate on the merits of profit maximization ensued (often referred to as the "marginalism controversy") and two alternative theories of firm behavior emerged.[1] Managerial theories, beginning with the work of Baumol (1959), Marris (1963), and Williamson (1963), suggested that the manager has control of the firm and may pursue objectives other than profit maximization. Behavioral theories, from the early contributions of Simon (1955) and Cyert and March (1963), instead proposed that the complexities of the economic environment make it infeasible to arrive at the profit maximizing prices.

Today profit maximization remains the standard assumption in modelling firm behaviour. It has more recently also become an important identifying assumption in much recent empirical work (Ackerberg et al., 2007, for references).

[1] See Silberston (1970) for a review of the arguments. Defenders of the hypothesis (e.g. Alchian, 1950, Friedman, 1953, and Machlup, 1947) maintained that it remained a good approximation even if firms may not be fully aware that they were maximizing profits. It was also claimed that significant deviations from it would eventually lead to the firm's demise; for some recent explorations of the validity of this see Blume and Easly (1992), and Dutta and Radner (1999).

Its strong standing is particularly noteworthy given the onslaught on expected utility maximization and consumers' rationality that has taken place over the last two decades or so. Perhaps the principal reason behind this state of affairs is that while consumer behaviour can be studied in controlled experiments no such option is open when it comes to drawing inferences about firms' behaviours. The large amount of empirical work that followed in the heels of the marginalism controversy relied almost exclusively on interviews with managers (Silbertson, 1970). The reason for why this did little to settle the matter is that without detailed knowledge about each firm's cost and demand situation as well as its particular strategic environment, it is impossible to know what the optimal prices would have been.[2] Thus, in order to test the hypothesis that firms set profit maximizing prices one needs to get a handle on what these are, as is done in this paper.

In this paper I provide a detailed case study of the pricing by a tobacco monopoly and test if it is consistent with maximization of the expected net present value (ENPV) of profits. The idea is to explore a setting where addictive properties of the product gives rise to an intertemporal link by which the current price influences not only its current profits but also the future demand and

[2] As an illustration, consider the basic Hotelling model where two profit maximizing firms each produce one variety. The Nash equilibrium prices depend not only on both firms' costs and their respective locations, but also on the order of moves (sequential or simultaneous). Furthermore, if the two firms were to meet repeatedly there might well be a multiplicity of equilibria. To empirically test if observed prices in such market are consistent with profit maximization, one would need to obtain estimates of all cost and demand parameters as well as somehow infer the nature of the strategic interaction.

thereby the long-term profit prospects. The advantage with a monopoly is that its dynamic optimization problem can be reduced to a simple Euler equation.[3] The empirical strategy here is then to estimate the demand and cost parameters, and the implicit discount factor from the Euler equation and a demand function for the product. I will reject the hypothesis of maximization of ENPV of profits if the estimated discount factor is significantly different from what would be *a priori* reasonable.

My data is from the Swedish Tobacco Monopoly (STM), and I focus on how it was pricing oral moist snuff over the period 1917-1959.[4] During this period STM had a state granted monopoly on production and could also both control the number of tobacco retailers and set retail prices for its products. Although all tobacco products contain nicotine and are naturally addictive, snuff offers several particularly attractive features for my purpose. First, STM owned and produced all brands (the type of type of snuff favoured in Sweden is distinctly different from what is available elsewhere). In contrast, STM itself imported several popular cigarette and cigar brands, and specialist retailers exercised

[3] Intertemporal linkages due to network externalites, consumer switching costs, and learning-by-doing are present in many oligopolistic industries. To test profit maximization in such settings is complicated by the fact that uniqueness of equilibria can not be guaranteed and the possible equilibria are often sensitive to the details of the model; see Farrell and Klemperer (2007).

[4] A number of papers have examined pricing behaviour of firms other tobacco markets but without taking into account that the product is addictive (e.g. Sullivan, 1985, and Sumner, 1981). Tan (2006) models addiction and advertsing in a structural model and use the assumption of Markov perfect equilibria to recover the deep parameters.

their freedom to import others. This suggests that it had more degrees of freedom in its pricing of snuff than other tobacco products. Second, a few brands remained dominant over the entire period and were priced almost identically. The reference price is for the brand Ljunglöfs Ettan, established in 1820 which in essentially unchanged form remains one of the most popular 185 years later (as of 2007, it had the second highest share of the Swedish market). For other tobacco types, there was considerable variation across brands. In the larger market for cigarettes there was high turnover of brands and the more expensive filter cigarettes with American tobacco gradually replaced the cheaper types without filter that used Turkish or Asian tobacco. Likewise, cigar sales also experienced shifts in popularity of different types. Finally, the product's consistency over time and the simple production technology allow me to use prior information to calculate a direct measure of the marginal cost that can be compared to the marginal cost that is econometrically estimated.

The results show that, throughout the period, STM priced well below the level that would have maximized ENPV of profits. The question is then whether STM priced to optimize some other objective, or if it indeed tried, but failed, to maximize ENPV of profits. My conclusion is that the evidence are hard to square with the implications of the maximization of some other objective function. The alternative explanation - that the firm either was unable to solve the dynamic optimization problem or had only imperfect information about the parameters of the problem - is difficult to reject as it offers few clear-cut predictions.

The work most closely related to the present is Levitt (2006).[5] He uses price and quantity data, together with prior information about marginal costs, from a firm delivering bagels and donuts at different locations. By deriving the expected marginal revenue and marginal cost of delivering additional units of the two items, Levitt shows that the firm could, at given prices, only very marginally improve profits by changing deliveries to some locations. The question then is whether the prices themselves are set at profit maximizing levels? With only four price adjustments over the 13-year sample period and lacking information about other demand drivers such as the firm's competitiors' prices it is not feasible to estimate demands. Instead, Levitt argues that since total revenues increased in the months immediately following the four price increases, the previous prices could not have been profit maximizing. However, while the short-run effect on quantities was limited, it is quite possible that the long-run demands are far more price sensitive.[6] Thus, without an explicitly dynamic, structural model it not possible to rule out that the firm's pricing was consistent with maximization of long-run proftis.

The paper is structured as follows. Section 2 presents the modelling framework, Section 3 describes the market and the data, Section 4 gives the economet-

[5] While not concerned with pricing, Romer (2006) examines the extent to which firms maximize. With data from play selections in American football he tests whether teams maximize the probability of winning. The findings suggest that there exist strategies, which in practice are rarely used, that would improve the chances of winning by nontrivial amounts.

[6] The regression results suggest that the positive effect on revenues disappeared after four to six months (the end of the event window). The company's owner is also reported to have been worried that any price increases would have had adverse effects on its long-term prospects.

ric results, and Section 5 discusses some alternative explanations of the findings.

2 Model

I model the pricing problem of a monopoly, whose future demand is partly determined by its current sales.[7] In a setting with addiction the maximization problem for the firm therefore involves a trade-off between high prices today to exploit current customers and low prices to build future demand.[8]

2.1 Monopoly profit maximization

The most direct way to derive the Euler equation is to let the state variable be the quantity sold in the previous period, Q_{t-1}, and the control variable the quantity sold in the current period, Q_t (of course, the result would be the same with P_t as the control variable). Let the inverse demand in period t be

[7] STM had a monopoly on all tobacco products and thus it should in principle take into account all the cross price elasticites its pricing. For instance, if snuff and cigarettes are substitutes its optimal price of snuff would be higher than if it only had a monopoly in the market snuff. However, as discussed below, empirically this cross price elasticty is small and not statistically significant. Therefore, the Euler equation is derived assuming that the two demands are independent of each other.

[8] Several papers have examined monopoly pricing decisions in markets with addictions without deriving or estimating the Euler equations. Showalter (1999) gives a first order condition for pricing that includes all future cost and demand variables. Becker et al (1994) also discuss how firms with market power has an incentive to price below the level that maximizes short run profits.

$P_t = P(Q_t, Q_{t-1})$ and the total cost be $C(Q_t)$.[9] The period t profit is then

$$\Pi(Q_t, Q_{t-1}) = P(Q_t, Q_{t-1})\, Q_t - C(Q_t)\,. \tag{1}$$

Under the null hypothesis that the monopoly is maximizing the expected net present value of profits the objective function is

$$\max_{Q_t,\ Q_{t+1},\dots,\ Q_{t+\infty}} E\left[\textstyle\sum_{s=t}^{\infty} \delta^{s-t}\Pi(Q_t, Q_{t-1})\,|\Omega_t\right], \tag{2}$$

where δ is a constant discount factor, and Ω_t the information available at t. The corresponding Bellman equation is then

$$V(Q_{t-1}) = \max_{Q_t} E\left[\Pi(Q_t, Q_{t-1}) + \delta V(Q_t)\,|\Omega_t\right]. \tag{3}$$

Using standard arguments for dynamic programming it is straightforward to derive the Euler equation from (3). Maximize (3) w.r.t. Q_t to get

$$V_t^{Q_t} = E[\Pi_t^{Q_t} + \delta V_{t+1}^{Q_t}|\Omega_t] = 0. \tag{4}$$

Next, differentiating (3) w.r.t. Q_{t-1} yields

$$V_t^{Q_{t-1}} = E[\Pi_t^{Q_{t-1}} + \delta Q_t^{Q_{t-1}} V_{t+1}^{Q_t}|\Omega_t] = E[\Pi_t^{Q_{t-1}}|\Omega_t], \tag{5}$$

where the second equality follows from the envelope property ($Q_t^{Q_{t-1}} = 0$ since a small change in the state does not influence the optimal choice of Q_t).

[9] Becker and Murphy (1988) model addiction as rational in the sense that buyers maximize the net present value of using an addictive good. Buyers therefore need to both take into account how their present consumption will change their demands in the future and be able to forecast future prices. The specification $P_t = P(Q_t, Q_{t-1})$ implies myopic buyers and/or buyers that can not make forecasts; often this is referred to as habit formation. I provide a simple test that suggest that modeling demand side as myopic is appropriate for this data set.

Moving (5) one period forward and substitute in (4) we obtain the Euler equation

$$V_t^{Q_t} = E\left[\Pi_t^{Q_t} + \delta\Pi_{t+1}^{Q_t}|\Omega_t\right] = 0. \tag{6}$$

2.2 Empirical implementation

In the empirical application, I employ a linear demand function

$$Q\left(P_t, Q_{t-1}\right) = \boldsymbol{\alpha}\mathbf{X}_t + \alpha^P P_t + \alpha^Q Q_{t-1}, \tag{7}$$

with inverse demand

$$P\left(Q_t, Q_{t-1}\right) = \frac{Q_t - \boldsymbol{\alpha}\mathbf{X}_t - \alpha^Q Q_{t-1}}{\alpha^P}, \tag{8}$$

where $\mathbf{X}_t$ is a vector of possibly endogenous demand shifters.

The technology is assumed to exhibit constant returns

$$C(Q_t) = \boldsymbol{\beta}\mathbf{W}_t Q_t, \tag{9}$$

where $\mathbf{W}_t$ is a vector of cost shifters.

For much of the sample period, there were both a unit tax and a tax on the retail price (*ad valorem*), K_t. Under the assumptions, the profit function (1) can be written as

$$\begin{aligned}\Pi\left(Q_t, Q_{t-1}\right) &= \left((1-K_t)(P\left(Q_t, Q_{t-1}\right) - \boldsymbol{\beta}\mathbf{W}_t\right) Q_t = \\ &\left(\frac{(1-K_t)\left(Q_t - \boldsymbol{\alpha}\mathbf{X}_t - \alpha^Q Q_{t-1}\right)}{\alpha^P} - \boldsymbol{\beta}\mathbf{W}_t\right) Q_t, \end{aligned} \tag{10}$$

where the unit tax is among the factors in $\mathbf{W}_t$.

Differentiating $\Pi(Q_t, Q_{t-1})$ and $\Pi(Q_{t+1}, Q_t)$ with respect to Q_t and some rearranging of the terms show that the Euler equation (6) can be written as

$$E\left[\left((1-K_t)\left(2Q_t - \boldsymbol{\alpha}\mathbf{X}_t - \alpha^Q Q_{t-1}\right) - \alpha^P \boldsymbol{\beta}\mathbf{W}_t - \delta\left(1-K_{t+1}\right)\alpha^Q Q_{t+1}\right)|\Omega_t\right] = 0. \tag{11}$$

3 Data[10]

3.1 The firm, product, and market

I study how the Swedish Tobacco Monopoly (STM) was pricing over the period 1917 and 1959, when it had a state granted monopoly on the production of all tobacco products, and could control the numbers of tobacco retailers and the retail prices of its own products. The sample period ends with the last year STM had its monopoly position.[11] For reasons spelled out in the introduction, I will focus on STM's pricing of moist snuff - a ground tobacco product taken between the gum and upper lip.[12]

[10]The historical details in this section draws on information in Munthe (1940) and Trolle (1965). The more recent information is taken primarily from the homepage of Swedish Match (http://www.swedishmatch.com). For information about the production process and health effects see the homepage of Gothiatek (http://www.gothiatek.com).

[11]STM became Svenska Tobaks AB (STA) in 1961, which merged with Svenska Tändsticksfabriken AB in 1992 and formed Swedish Match AB. As of 2007, Swedish Match retains an estimated 99 percent share of the Swedish snuff market and has high market shares in cigars and pipe tobacco; it sold its cigarrette division in 1999.

[12]Moist snuff has been used in Scandinavia since the late 1700s; similar products are available in the USA, South Africa, India, and Russia. As of today, sale of moist snuff is banned

In the early 1900s, several costly social reforms were introduced and it became urgent to find a way to finance these. Taxes on tobacco, until then only subject to minor import duties, was generally seen as the ideal vehicle and the main divisive issue was from who taxes should be collected. Proponents of the creation of a tobacco monopoly successfully argued that administrative costs involved in taxing the large number of existing small tobacco firms (in 1908, there were over 100 and an unknown number of artisan producers) were prohibitive. The outbreak of World War I in 1914 stretched the state's finances even further and it was deemed impossible to buy-out existing producers without the help of private financiers.

When STM came into existence in 1915, its equity was provided by six large commerzial banks (SEK 12m - in 2007 prices about SEK 500m or USD 65m) and the state (SEK 17m). Although the private financiers had a minority stake they were nevertheless entitled to appoint four of the eight board members. The operative control of the company was largely left to those appointed by the banks as they had more business experience than the others.

The contract between the state and the company, of which the most important clauses for this paper are translated in Appendix A, was signed in February 1915. In this it was stated that the monopoly rights were to be renewed at 10 year intervals and that operative decisions should be efficient. In terms of pricing decisions, the company faced no restrictions other than, if possible, that it

within the European Union with the exception of Sweden. Compared to the massive scientific evidence that has emerged regarding smoking's negative health effects since the Terry Report (1964), there remains preciously little evidence to suggest that use of moist snuff is associated with serious health hazards.

should aim at treating all product groups in a symmetric fashion.

During the monopoly years, STM produced virtually all snuff and pipe tobacco but imported some of the more popular cigarette and cigar brands. It was until 1947 also possible for licenced specialist retailers to import foreign brands through STM. This opportunity was exercised for cigarettes and, in particular, cigars but was virtually non-existent for snuff since the type of moist snuff favoured in Sweden is quite distinct from the dry snuff available in other countries.[13]

3.2 Variables

Sources and details of variable definitions are given in Table 1.

3.2.1 Demand

Snuff was consumed almost exclusively by men. To account for demographic changes that occurred over the period, I measure volume by the per capita consumption for the male population +20 years, Q.[14]

Retail prices for snuff were set by STM and did not vary across outlets and there was very limited variation in prices between brands. I use the real price per kilo of the brand Ljunglöfs Ettan, P, which has remained one of the

[13] For cigarettes and cigars the private import share reached up to 12 and 56 percent respectively. For snuff, private imports were always less than 0.5 tonnes out of a total of 2600-7000 tonnes!

[14] This group increased from 1.6m to 2.6m reflecting a population that was both growing (from 5.7m to 7.6m) and ageing (males +20 years increased from 29 to 34 percent).

most popular since its introduction in 1820.[15] Since snuff contained tobacco types that were unavailable towards the end of World War II, I use the price of Rikssnus for 1943–1945.

The closest substitute product category is cigarettes; cigars were much more expensive and pipe smoking relatively uncommon during the period. The demographics of smokers were quite distinct, however, as cigarettes were consumed mostly in urban areas and also, especially after World War II, by women. Since the cost of smoking was higher (an average smoker might spend 4-6 times more than a typical user of snuff) smoking was also more prevalent in higher socio economic groups. Judging by STM's price lists, cigarette prices varied considerably due to differences in size and origin of tobacco; filter cigarettes also tend to be more expensive. I have decided to use the price of a common mid-size cigarette with filter containing American blended tobacco, P^C. I have, however, experimented with prices of other basic types (such as non-filter) and results reported below appear robust to this.

Income per capita, $GDPCAP$, is included and might have a negative effect on consumption as more took up cigarette smoking when the standard of living increased. I also include a dummy variable for the period after World War II, $POSTWAR$.

[15] Statistics Sweden includes Ljunglöfs Ettan in its Consumer Price Index, and real and nominal retail price since 1931 can be found at http://www.scb.se.

3.2.2 Costs

Moist snuff contains three main ingredients: pulverized tobacco leafs, water, and salt; some brands also contained small amounts of flavour additives. Only tobacco, making up 45 percent by weight, has any measurable impact on the costs. The exact composition is not revealed but it is known that several types of primarily high grade, dark air-cured tobaccos are used and that these were imported almost exclusively from the USA (during the last years of World War II, these were substituted with domestically grown tobacco and occasional supplies from various sources). I measure the tobacco cost with the average annual price of dark air-cured tobaccos (Types 35-37 in the USDA classification) in SEK/kg, W^1; see Table 1 for details. This is a lower bound of the actual cost, given that snuff contains higher than average grades and also some typically more expensive light tobacco types.[16]

For STM, a factor of great importance was taxation. Snuff was subject both to an *ad valorem* tax, K, and a unit tax, W^2. For the empirical specification, the *ad valorem* tax rate is deducted from the retail price as shown by (10). The unit tax per kilo is included among the cost variables.

The labour employed in snuff production were mostly unskilled and the closest category for which data on hourly wages, W^3, is available is "Workers

[16] Tobacco prices may differ but are highly correlated over time and the use of one price index should capture the relative development of the cost of tobacco. For the period 1935-1959 (1935-1944) the average price (in (SEK/kg) of types 11-14 (light flue-cured), 21-24 (fire-cured), 35-37 (dark air-cured), and 41-65 (cigar tobaccos) were 1.56 (1.23), 0.98 (0.64), 0.87 (0.60), and 1.61 (1.23), respectively. The correlation of types 35-37 with types 11-14, 21-24, 41-65, were 0.84 (0.77), 0.93 (0.91), 0.80 (0.86), respectively.

in food, drinks and tobacco industries". Labour productivity growth was slow - based on information on the number of workers in snuff production and an assumption about average working hours, it increased only by 30 percent over the 43-year period.

As noted above, STM fixed the retail price at the independent outlets. The compensation to sellers was formally calculated as a percentage rebate on the retail price. In practice, however, the compensation was in real terms approximately constant per kilo, as STM was reducing the percentage to offset increases in the retail price caused by increases in taxes.[17]

In Table 2, I illustrate an approximate breakdown of the marginal cost, MC, in 1925 and 1950, and the resulting price - cost margins; for the full period it is illustrated in Figure 1. In providing an estimate of the cost per kilo of all major cost components I draw both on the input prices discussed above and other information about STM. The marginal cost of the raw material is essentially the tobacco price (in SEK per kilo) times the average tobacco content in snuff (approximately 45 percent). The unit tax is in SEK per kilo. To give a crude estimate of the labor cost per kilo we use labour productivity per hour times the hourly wage.[18] The selling cost is the retail price times the percentage rebate

[17] For the sample period, the retailer's compensation per kilo in real terms was on average 0.37 with a standard deviation of only 0.035 (see Figure 2 below). Given that the real retail price almost doubled over the period this suggest that STM's control over the percentage rebate allowed it to keep real compensation roughly fixed.

[18] To calculate productivity, I use the number of workers in snuff production (from Trolle 1965) and multiply this with an assumption about the average number of hours worked, which is then divided with the annual production. The number of hours per worker is taken to be

given to the retailers (Trolle, 1965). The cost of distribution is taken to be the same percentage of revenue as for STM as a whole (Trolle, 1965). It is, however, possible that this amounts to an underestimate of the true costs since snuff has a lower unit value than cigarettes and cigars.

From Table 2 and Figure 1 it is evident that the most important components of the marginal cost are the unit tax, the tobacco cost, and the compensation to the retailer. Labor cost and distribution cost are comparatively low. Given this, and the fact that there is little time variation in these two variables, these will be part of the constant term in the econometric specification of marginal cost. Likewise, there is over the sample period 1917-1959 limited variation of the compensation to the retailers and it will also be part of the constant term.

In Figure 2, the retail price gross and net of the *ad valorem* tax rate are illustrated together with the approximate marginal cost, and the absolute and relative price-cost margin. The most notable facts from this is that net prices closely follows marginal costs and that margins are gradually falling over time; the relative margin fell from about 0.6 to 0.2 at the end of the sample period.

4 Econometric results

The full model involves estimating the demand function (7) and the Euler equation (11) jointly by GMM. Before turning to this, I estimate (7) separately in order to judge whether the restrictions imposed by the joint estimation, where demand parameters enter the Euler equation, drive the results.

2500 in 1916 and reduced by 20 hours per year thereafter.

4.1 Estimates of demand parameters

Together with the preferred GMM specification I report both LS and 2SLS estimates of the demand function (7). I also estimate GMM specifications with Q_{t-1} excluded as well as with P_{t+1} included. The reported GMM standard errors account for both heteroskedasticity and auto correlation. The point estimates for most coefficients are similar in the first three columns although the standard errors are inconsistent for LS (possible endogenity of P_t and auto correlation) and 2SLS (auto correlation).

In column 1, the only variable treated as endogenous is the price of snuff.[19] It is instrumented with taxes of snuff and cigarettes, wages, and two tobacco prices and the overidentification restrictions can not be rejected.

Turning first to the price elasticities. To the short-run demand function there is a corresponding long-run demand function, obtained by setting $Q_t = Q_{t-1}$ in (7)

$$Q\left(P_t\right) = (\boldsymbol{\alpha}\mathbf{X}_t + \alpha^P P_t)/(1 - \alpha^Q). \tag{12}$$

The coefficient of the snuff price is -0.29 which corresponds to an average short-run price elasticity ($\epsilon^S = -\alpha^P P_t/Q_t$) of 0.60.[20] The long-run price elas-

[19] Excluding the cigarette price as an instrument (i.e. treating it as endogenous) gives a J-statistic of 0.125. This single overidentifying restriction can be tested and N*(0.175-0.125) is distributed as Chi(1) and it can not be rejected at the 10 percent level.

[20] As a comparison, the demand elasticity of ciggarettes is typically found to be around 0.4 (Gallett and List, 2003).

ticity, $\epsilon^L = -\alpha^P P_t / Q_t (1 - \alpha^Q)$, is 2.10. The fact that the short run price elasticity is below unity implies that the firm could raise short-run profits by raising its price (note that the existence of an ad valorem tax only reinforces this point). The firm is, however, pricing on the elastic portion of the long-run demand function and we can thus not a priori say that its prices are too low to maximize long run profits.

How much steeper the short-run demand is than the long-run demand is illustrated in Figure 3 with values of $\mathbf{X}_t$ and Q_{t-1} from 1935 - a year when the actual price was 2.84 and the sold volume was 2.09. As visible in the figure, the estimated short-run demand function suggests positive volumes for prices more than three times the actual. It must be noted, however, that extrapolating a demand curve well beyond the observed range of prices is fraught with difficulties as it relies on the functional form assumption. Nevertheless, the development of volumes over the relatively short time period 1938-1946, when price increased sharply, should dispel any doubt that the demand is quite insensitive even over a substantial range of prices in the short run. During these years, a price increase of 76 percent (from 2.66 to 4.70) was accompanied by a fall in volumes of only by 26 percent (from 1.97 to 1.46).

The coefficient α^Q is 0.71 which reveals a very strong intertemporal demand link. To show how the intertemporal demand link interacts with the short-run price elasticity, Figure 4 illustrates the 1936 demands that would result for a different 1935 price. In 1935, STM set a price of 2.84 which, according to the estimated demand, gives a volume of 2.18; a 33 percent higher price had given a volume of 1.90. As is evident in the figure, higher current prices translates into lower future demand and the challenge for the company is the get the profit trade-off right.

The coefficient of the cigarette price is positive (the implied average cross price elasticity is 0.12) but it is not statistically significant. That the two markets are largely independent is not surprising given that the demographic composition of snuff users differed considerably from smokers. This is also supported by the results in Table A in the Appendix, where I re-estimate the demand for snuff and as well as the demand for cigarettes. Overall, cross-price effects are not statistically significant in either of the regressions.[21]

The income effect is negative. As noted before, snuff use was most widespread in lower socio economic groups. As incomes rose, greater numbers could afford the more expensive cigarettes.

The specification without Q_{t-1} (Column 4), which ignores the addictive nature of consumption, is distinctly different in terms of point estimates but the explanatory power remains high (R-square above 0.88). The most notable difference is the average own price elasticity. Comparing to the previous estimates, it is four times the average short-run elasticity, and even slightly higher than the average long-run price elasticity.

The demand specification (7) implicitly assumes that consumers are myopic

[21] It turns out that the demand specification for cigarettes is more sensitive than that for snuff. For comparison I estimate both by 2SLS and treat all prices as endogenous. In the cigarette equation the coefficient on cigarette price is negative but not statistically significant and the implied own price elasticity of 0.16 is lower than is commonly found (most studies find values around 0.4; Gallet and List, 2003). In neither equation is the cross price effect statistically significant.

or unable to predict the future cost of their consumption, since current demand only depends on past consumption and current prices. Becker and Murphy (1988) model addiction as rational, in the sense that the consumer also takes into account that the current consumption will also influence future costs. The limited variation in the present data set (43 observations) precludes a formal test of the common rational addiction model.[22] However, a direct implication is that the current demand should partly depend on future prices. In the last column, next year's price, P_{t+1}, is included and instrumented with taxes for that year, K_{t+1} and W_{t+1}^2. The coefficient on P_{t+1} is not statistically significant. While this should not be taken as definite proof that snuff users are not rational it nevertheless suggest that treating them as myopic or unable to forecast future prices is not unreasonable.

4.2 Estimates of Euler equation

From the Euler equation (11),

$$E\left[\left((1-K_t)\left(2Q_t-\boldsymbol{\alpha}\mathbf{X}_t-\alpha^Q Q_{t-1}\right)-\alpha^P\boldsymbol{\beta}\mathbf{W}_t-\delta\left(1-K_{t+1}\right)\alpha^Q Q_{t+1}\right)|\Omega_t\right]=0,$$

we define an error term as

[22] Many different formulations of rational addiction models have been taken to empirical testing. Becker et al. (1994), using a panel of cigarette sales across US states, include future consumption as a regressor, and instrument it with with future prices and costs. Choloupka (1991), analysing individ level data on smoking, adds both past prices and future prices as well as future consumption. See e.g. Gruber and Kōszegi (2001) and Baltagi and Griffin (2001) for some discussion of the interpretation of the various specifications that have been employed.

$$v_t = \left(\left((1 - K_t)\left(2Q_t - \boldsymbol{\alpha}\mathbf{X}_t - \alpha^Q Q_{t-1}\right) - \alpha^P \boldsymbol{\beta}\mathbf{W}_t - \delta\left(1 - K_{t+1}\right)\alpha^Q Q_{t+1}\right)\right). \tag{13}$$

Under the assumption that the firm has rational expectations, the conditional expectation of (13) is zero:

$$E\left[\boldsymbol{v}_t|\Omega_t\right] = 0. \tag{14}$$

From the currently available information a set of orthogonality conditions is formed

$$E\left[\mathbf{Z}_t\boldsymbol{v}_t|\Omega_t\right] = 0. \tag{15}$$

Among the orthogonality conditions I first include the exogenous variables in $\mathbf{X}_t$, the exogenous input prices $\mathbf{W}_t$, and the ad valorem tax rate for snuff, K_t. I also include the remaining instruments that were used in estimating the demand function - the ad valorem tax rate and per unit tax of cigarettes (K_t^C and W_t^{2C}) and light tobacco prices (W_t^{1C}). Taxes were rarely adjusted but when they were it was announced in advance. Therefore I include both the next year's ad valorem tax rate, K_{t+1}, the unit tax, W_{t+1}^2, among the orthogonality conditions.

Table 4 shows the results from a three GMM estimations. First, a joint estimation of (11) and (7). Second, estimation of (11) with the demand parameters $\boldsymbol{\alpha}$, α^Q, and α^P restricted to the point estimates in Column 1 in Table 3. Finally, estimation of the demand parameters with the cost parameters, $\boldsymbol{\beta}$, set to the values that are a priori plausible and the discount factor set to unity.

The joint estimation gives broadly similar demand parameter estimates to those in Table 3. The long-run price elasticities are almost identical but the short-run price elasticity is considerably lower.

The estimates of the components in the marginal cost have the expected signs and are plausible in magnitude. In particular, the coefficient of the unit tax is 0.97 and the expected value of 1.00 is well within 95 percent confidence interval. The coefficient on the tobacco price is 0.69 with a standard error of 0.101. Despite being higher than the tobacco content in snuff (0.45) it is still reasonable. The discrepancy is most likely stemming from the fact that W^2, the average price of dark-air cured tobaccos, probably underestimates the cost as more expensive types and qualities make up a significant portion. The constant term is 0.63 which can be compared to the average sum of cost components other than tobacco and unit tax (i.e. cost of labour, selling, and distribution) which is 0.47 in Table 1. One possible explanation is that the direct calculation of these costs somewhat underestimates the true costs.[23]

That the specification is doing well in capturing cost parameters is evidenced in Figure 5. Over the period, the marginal cost estimated as $\boldsymbol{\beta}\mathbf{W}$ closely tracks MC, which was calculated using prior information. This consistency provides support to the empirical specification.

There is a strong prior that the real discount factor, δ, should be below

[23] The selling cost, S, was approximated by $s \times P$, with s being the average (across all tobacco products) percentage rebate to sellers. However, it is likely that the percentage compensation for selling snuff was higher than for higher unit value products as cigarettes, cigars, and pipe tobacco.

unity.[24] The estimate of the discount factor δ is 1.21 which, given a standard error of 0.047, is significantly above unity. The implication of this is that the firm is pricing too low relative to long-run profit maximization. Stated differently, STM is too concerned with building and maintaining the stock of customers and not aggressive enough in extracting profits from the current users.

Is this result due to too much structure being imposed on the econometric specification? The demand parameters α, α^Q, and α^P appear both in (7) and (11) and a joint estimation of a too highly structural model may drive the estimates of other parameters such as δ and $\boldsymbol{\beta}$. One indication of this is that the short-run elasticity is 0.35 in Table 4 is against 0.60 in Table 3. To test this we restrict α, α^Q, and α^P to the values obtained in estimating the demand function separately and estimate only δ and $\boldsymbol{\beta}$ in the Euler equation by GMM.

The estimates of $\boldsymbol{\beta}$ are broadly in line with those from a joint estimation. However, the estimate of δ is now higher still at 1.42. Thus, if anything, the firm is actually even further from long-run profit maximization.

Finally, consider the possibility that STM is in fact trying to maximize ENPV of profits with a reasonable discount factor and knows its costs well but for some reason believes the demand function is different from that estimated here. To see which demand function that would be consistent with these assumptions, I use only the Euler equation to estimate the demand parameters while restricting the other parameters. Here I use the prior information about the marginal cost to restrict the β-parameters to $\beta^0 = 0.47$ (the mean of S+L+D),

[24] The average real interest rate on government bonds over the period was 2.8 percent which corresponds to a discount factor of 0.97

$\beta^{W^1} = 1.00$ and $\beta^{W^2} = 0.45$ (the percentage raw tobacco in snuff) and setting $\delta = 1.00$.[25]

The demand parameters in Column (3) in Table 4 all have the expected signs but significance levels are generally lower than in Column (1) in Table 3. The main differences are that α^P and α^Q are now -0.18 and 0.90 against -0.29 and 0.71 before.

4.2.1 Actual, optimal and myopic prices

To get a sense for the difference between the actual and the optimal prices, note that the dynamic programming problem in Section 2.2 is similar to a discounted optimal linear regulator problem (see e.g. Ljungqvist and Sargent, 2003). Standard software for solving this type of problem is readily available - here I use the Matlab code `olrp.m`.

The profit function (10) can not be written exactly in the quadratic form (see (A1) in the Appendix) as the one of the state variables, K_t, is interacted with the quadratic term. However, by treating K_t as a parameter the problem becomes a linear regulator problem. The cost of this simplification is that in every period K_{t+1} is assumed to be the same as K_t. This does not cause any problem in periods when the ad valorem tax rate is known to stay the same but will not give the correct policy when taxes are known to change. Significant tax changes occurred only six times (1922, 1924, 1927, 1940, 1951, and 1954) so most of the optimal prices are unaffected by this.

[25] Using slightly different values of the β-parameters and δ yields similar estimates of the α-parameters.

In Figure 6, the actual prices are graphed together with optimal and myopic prices. The optimal and myopic prices are based on the demand parameters in Column (1) of Table 3 and the cost parameters in Column (1) in Table 4; for the optimal prices given a $\delta = 1.00$ and for the myopic $\delta = 0$.

The most striking feature of the figure is that the optimal prices is far higher than the actual in the early period. The gap gradually narrows, however, in particular after World War II. That the optimal prices far exceeds the actual in the early period suggest that STM then priced too low, given the customer stock it had inherited. In the next section, I discuss some alternative explanations for this.

Myopic prices are, of course, even higher than the optimal but the difference narrows in the post war period. In Figure 8, I illustrate the short-run demand curve as of 1935 together with the marginal cost (estimated from $\boldsymbol{\beta}\mathbf{W}$) being 1.25. This year the actual price was 2.84 and the sold quantity was 2.09. With an *ad valorem* tax of 0.38, the net profit (10) was 1.07 per capita, as given by the area A+B in the figure. The myopic price[26] was 6.20 corresponding to a quantity of 1.20. The net profit per capita (10) is 3.10, given by the area B+C in the figure. This simple example shows STM could increase short-run profits threefold by charging higher prices.

[26] The myopic price can be calculated directly. To the estimated demand curve, there is a corresponding marginal revenue curve, MR_t, but given the *ad valorem* tax, K_t, STM's marginal revenue is $(1 - K_t) * MR_t$. The myopic price is found by solving $(1 - K_t) * MR_t = \boldsymbol{\beta}\mathbf{W}_t$,

5 Discussion

In this paper I have examined the Swedish Tobacco Monopoly's pricing during the period when it had a state granted monopoly on the production of all tobacco products and could also control retail prices. The results reject the null hypothesis that STM priced to maximize the expected net present value (ENPV) of profits. Over the entire sample period, prices of moist snuff remained well below those that had maximized ENPV of profits.[27] The question is whether this was a deliberate choice or that it tried but failed. To answer this, I begin by examining whether the state's various roles in the market can explain the company's deviation from profit maximization. Having argued that this is implausible, I thereafter discuss the evidence in the light of managerial theories, and make some remarks on whether its behaviour is consistent with behavioural theories of the firm.

5.1 The state's role(s) in the market

The company was partly owned by private investors which, according to available documents, had considerable discretion in running it. However, the state played several roles in the market. Not only did it grant the initial monopoly rights and renewed these at ten year intervals, but it also had an equity stake in the company and set tobacco taxes. One might therefore ask if STM's behaviour

[27] Demand for snuff was found to be statistically independent of that of cigarettes, which was presumably the closest substitute. If STM in fact took the substitutabilty between the two products into account in setting prices it would, of course, have resulted in even higher optimal prices than those predicted here.

is solely a reflection of the state's objective function, which might well be quite different from maximization of ENPV of profits. While it is, of course, impossible to know exactly what this objective function might have been we can still see if predictions from some reasonable alternatives match the observed patterns.

5.1.1 Maximizing ENPV of the state's net revenue

The tobacco monopoly was instigated to finance costly social reforms and higher military spending, and between 1916 and 1959 the state derived on average almost 10 percent of its incomes from tobacco taxes. A natural candidate is that the objective was to maximize the ENPV of the state's net revenues from the market.

To see the implications for pricing note first that had the market been nationalized, as was discussed at the time, taxes would have been pure transfers and therefore irrelevant. Thus, in this setting the problem of maximizing the ENPV of net revenues is equivalent to maximizing ENPV of profits in the absence of taxes; the problems are identical if the are no differences in discount factors or productive efficiency. The factual situation, however, was that the state owned only a share of the company, and the issue is whether it would have preferred prices lower than those that would maximize ENPV of profits. Let us, for the sake of argument, begin by assuming that whatever its ownership stake the state could control both the unit tax and the price. Further, assume its choices are subject to a zero (without loss of generality) minimum required return for the private investors. With two instruments at its disposition the state can capture all rents by choosing (again!) the price that maximizes the ENPV of profits in the absence of any tax, and then set the unit tax equal to this price. The implication is that the price should be determined solely by demand, cost factors other than taxes, and the discount factor. Any look at the data reveals that taxes do play a role for its pricing. Next, let us alternatively assume the company takes taxes as exogenous but it still aims to maximize the ENPV of net revenues, again under a zero minimum return for the private investors. Here there is actually a conflict of interests as the optimal price is negatively related to the state's ownership stake. Intuitively, by pricing lower it sacrifices its share of a lower profit but in return gains higher tax revenues through higher volumes. A direct implication is that, for a given ownership structure, there is a negative (rather than positive!) relation between taxes and the optimal price. Even a cursory look at Figure 3 suggests that is not borne out by the data. The conclusion from all this is that the patterns can not be explained by the company acting to maximize the state's ENPV of net revenues.[28]

5.1.2 Other considerations for the state

Could prices and taxes then, if chosen by the state, have been selected to achieve objectives in addition to raising revenues? Given that moist snuff is a tobacco product, many of which have negative health effects, one might conjecture that prices were chosen with at least a partial view of limiting consumption. This can not explain STM's operations, not only because health concerns were not an issue at the time but these would give a bias towards prices higher (rather than

[28] Of course, had the state been desperate to raise money directly after STM was founded it would have behaved more like a myoic firm and had set higher prices than those that would maximize ENV of profits.

lower) than those that maximize the state's ENPV of net revenues. Consider the opposite assumption - the state wanted to provide an inexpensive product to addicted users. At first this seems inconsistent with tax increases that allowed the real retail price to more than double. One can, however, make the counter argument that the gradual decline in the number of users reduced the weight put on their utility. While this can not be refuted directly, it is hard to reconcile with the largely parallel increases cigarette taxes, where the number of users increased dramatically. Another possibility, given exogenous factors that resulted in falling snuff consumption, is that prices were kept low in an effort to keep volumes from falling even further with job losses as a consequence. While total snuff consumption fell by more than 50 percent over the 45-year period, the decline was gradual and it is unlikely that any workers ever risked being fired as a result of lower demand. Moreover, the company could easily have transferred any redundant workers (almost all of which were unskilled) to its booming cigarette business. The bottom line is that the observed price pattern is difficult to reconcile with how a state controlled company would have priced if it put some weight on other factors than maximizing the ENPV of its net revenues.

5.2 Managerial theories of the firm

In managerial theories of the firm, the manager may pursue other objectives than those of the owners. It is often suggested that managers may sacrifice profits for higher sales, and that they are too interested in the short-run performance of the company. This fail to account for STM's pricing as both would work towards having higher prices than those maximizing the ENPV of profits. First, since the firm is operating on an inelastic part of the demand curve, raising prices would increase both sales and profits. Second, a manager focusing on short-run performance would also boost short-run profits by raising prices, despite the fact that this leads to lower long-run profits.

There is also the possibility the STM's managers might have priced low in order to avoid the unpleasant task of firing employees. This is unlikely since, as discussed in the preceding section, the decline of the market for snuff was slow and was in any case more than offset by the growth in the cigarette market.

It is difficult to find any managerial objective function that would make its pricing consistent with the observed pattern. Would the company's private owners have wished to price below the level that maximized ENPV, aside from the considerations mentioned above.

One possibility is that it engaged in limit pricing and it tried to convince other potential firms that profits in this business were low. This is unlikely for at least two reasons. First, the market was highly transparent and, given the simple technology, it would have been easy for any outsider to calculate production costs. Second, it held a state granted monopoly. A related possibility is that it priced low in order to limit smuggling. Going over STM's annual reports one finds several references to cigarette smuggling but no concerns about snuff smuggling. The most likely explanation is that cigarettes were widely available abroad while, as mentioned before, the type of moist snuff favoured in Sweden was not sold elsewhere.

5.3 Behavioural theories of the firm

Did STM deviate from profit maximizing because it could not solve the dynamic optimization problem or did it not know the parameters of the problem? While there is an emerging literature modelling firms as boundedly rational (see Ellison, 2006, for references), few predictions can be made on how such firm would price. For instance, depending on whether it over- or underestimated the price elasticity of demand it might have priced too low or too high, relative to the level that would have maximized the ENPV of profits.

Two brief remarks can nevertheless be made on STM's behaviour. First, it does not appear to be pricing according to the simple rule of thumb that markups over costs should be constant, as both absolute and relative margins are falling more or less montonically over time. Second, its pricing comes gradually closer to maximization of ENPV of profits which might suggest that it is learning about the parameters over time. It is easy to believe that uncertainty regarding the demand was great soon after the monopoly was created in a previously competitive market with dozens of producers and retailers that were free to set prices. However, even 10-20 years after the its creation, the monopoly priced well below the level that would have maximized profits. Moreover, judging from the observed prices, there were no obvious attempt to experiment and thereby learn more about the parameters.

6 References

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7 Appendix A

Translation from Swedish of the three most important paragraphs in STM's contract with the state.

"Contract between the Swedish state and the Swedish Tobacco Monopoly, 12 February 1915.

§7 It is the company's responsiblity to save on costs and in every way make sure that the production is rational and efficient, and in deciding the list prices, that the burden, which is intended to generate profit to the company, as far as possible, is divided evenly across all product groups.

§14. This contract is valid until the end of 1924 and will be renewed thereafter with ten year intervals, if it is not terminated by the state. Termination has to be announced at least 6 months before the contract's expiration. The company can not terminate the contract.

§15. If the state uses its right to terminate the contract, the state is obliged at the end of the contract term to purchase all the preference shares in the company to the nominal value plus their profit share for the latest accounting year."

"Kontrakt mellan svenska staten och Aktiebolaget Svenska tobaksmonopolet den 12 februari 1915.

§7 Det åligger bolaget för vinnande av största möjliga besparing i omkostnader att å alla områden av dess verksamhet anordna driften på det mest rationella och effektiva sätt ävensom att det vid fastställande av priskurantpris iakttage, att den belastning, som avser att lämna vinst å rörelsen, kommer att vila i möjligaste mån jämnt å alla varuslag".

§14. Detta kontrakt gäller till utgången av år 1924 samt förlänges sedemera för tio år i sänder, där ej från statens sida uppsägning sker. Uppsägningen skall ske minst 6 månader före kontraktets utlöpande. Fran bolagets sida är kontraktet ouppsägbart.

§15. Begagnar staten sin rätt att uppsäga kontraktet, skall staten vara skyldig att vid kontraktstidens utgång inlösa samtliga preferensaktier i bolaget till nominella värdet med tillägg av den å aktierna belöpande vinst för sista räkenskapsåret."

8 Appendix B

In the notation of Ljungqvist and Sargent (2003), let the single control variable be u_t and the vector of n state variables be x_t. For a quadratic problem the objective can be written on the general form

$$\max_{u_t,\ u_{t+1},\ldots,\ u_\infty} E[\textstyle\sum_{s=t}^{\infty} \beta^{s-t} \left(x_t^{'} R x_t + u_t^{'} Q u_t + 2u_t^{'} H x_t \right)], \tag{A1}$$

where in our setting x_t is $n \times 1$, R is $n \times n$, p_t and Q is 1×1, and H is $1 \times n$. The state variables evolve as

$$x_{t+1} = A x_t + B u_t + C\epsilon_t \tag{A2}$$

where A is $n \times n$, B and C are $n \times 1$, and ϵ_t is a $n \times 1$ vector of stochastic disturbance terms.

The optimal policy rule u_t is given by[29]

$$u_t = -(Q + \beta B' P B)^{-1} (\beta B' P A + H) x_t \tag{A3}$$

where P solves the algebraic matrix Riccati equation

$$P = R + \beta A' P A - (\beta A' P B + H\prime)(Q + \beta B\prime P B)^{-1} (\beta B\prime P A + H) : \tag{A4}$$

Under the assumption that $K_t = K_{t+1}$ and $W_t^2 = W_{t+1}^2$, the profit function (10) can be put in the form of (A1) and (A2) with the following matricies:

[29] Note that for a quadratic problem the stochastic properties of ϵ_t do not feature in the optimal policy (see e.g. Ljungqvist and Sargent, 2003)

$$x_t = \begin{bmatrix} 1 \\ Q_{t-1} \\ P_t^C \\ GDPCAP_t \\ PW_t \\ W_t^1 \\ W_t^2 \end{bmatrix}, \; A = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}, \; B = \begin{bmatrix} 0 \\ 1 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$R = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}, \; Q = \frac{(1-K_t)}{\alpha^P}, \; H' = -0.5 \times \begin{bmatrix} \frac{(1-K_t)\alpha_0}{\alpha^P} + \beta_0 \\ \frac{(1-K_t)\alpha^Q}{\alpha^P} \\ \frac{(1-K_t)\alpha^{P^C}}{\alpha^P} \\ \frac{(1-K_t)\alpha^{GDPCAP}}{\alpha^P} \\ \frac{(1-K_t)\alpha^{PW}}{2\alpha^P} \\ \beta^{W^1} \\ \beta^{W^2} \end{bmatrix}$$

TABLE A. ESTIMATES OF DEMAND FOR SNUFF (1) AND CIGARETTES (2).

	2SLS (1)	2SLS (2)
Dependent variable	Q	Q^C
DEMAND		
PRICE SNUFF	-0.383***	0.034
	[0.140]	[0.067]
PRICE CIGARETTES	0.825	-0.305
	[0.521]	[0.296]
QUANTITY LAGGED	0.710***	0.780***
	[0.099]	[0.064]
GDP/CAP	-1.078**	0.244
	[0.491]	[0.224]
POSTWAR	0.317**	0.285***
	[0.140]	[0.067]
CONSTANT	1.914***	0.117***
	[0.657]	[0.081]
AVERAGE OWN-PRICE ELASTICITY		
SHORT-RUN	0.78	0.16
LONG-RUN	2.60	0.71
AVERAGE CROSS-PRICE ELASTICITY	0.23	0.11
R-SQUARE	0.984	0.987
DURBIN-WATSON	1.293	1.453
OBSERVATIONS	42	42
YEARS	1917-1958	1917-1958
INSTRUMENTS	A1	A2

ESTIMATES BY TSP 4.5. [STANDARD ERRORS] SIGNIFICANCE LEVELS: * = 10 % , ** = 5 % AND *** = 1 %

A1) INSTRUMENTS: C, P(-1), P^C(-1), Q(-1), GDPCAP, POSTWAR, K, K^C, W^1, W^{1C}, W^2, W^{2C} ,W^3

A2) INSTRUMENTS: C, P(-1), P^C(-1), Q^C(-1), GDPCAP, POSTWAR, K, K^C, W^1, W^{1C}, W^2, W^{2C} ,W^3

TABLE 1. VARIABLE DEFINITIONS AND DESCRIPTIVE STATISTICS[A)]

Variable	Description and source	Mean; St.Dev. [Min;Med;Max]
P	Retail price per kilo of moist snuff. Price was set by the Swedish Tobacco Monopoly. The brand is Ljunglöfs Ettan except for 1943-1945 when only the substitute Rikssnus was available. Source: Svenska Tobaksmonopolets Priskuranter, which can be found at the Swedish Royal Library in Stockholm.	3.38, 0.88 [1.95;2.98;4.81]
Q^{TOT}	Total volume snuff in millions kilo. Source: Statistisk Årsbok.	4.29;1.19 [2.61;4.43;7.00]
POP	Male population +20years old in millions. Source: http://www.scb.se	2.15 ;0.28 [1.68 ;2.19 ;2.58]
Q	Per capita volume in kilo snuff per capita for the male population +20 years. $Q= Q^{TOT} /POP$.	2.09; 0.86 [1.01;1.97;4.04]
P^C	Retail price per 20 cigarettes, as set by the Swedish Tobacco Monopoly. The type is with filter, medium-size, and contains American tobacco. The brand is Commerze (1916-1942), Florida (1943-1946), and Sana (1947-1959). Source: Svenska Tobaksmonopolets Priskuranter.	0.54;0.19 [0.29;0.43;0.87]
Q^{TOTC}	Total volume cigarettes in billion pieces. Source: Statistisk Årsbok.	2.72;1.65 [0.89,2.00;6.32]
Q^C	Per capita volume in 100 cigarettes for the male population +20 years. $Q_C = Q^{TOTC} /POP$	4.03;2.11 [1.53;3.24;8.36]
GDPCAP	Gross domestic product per capita. Source: Statistisk Årsbok.	0.54;0.17 [0.28;0.53;0.90]
POST-WAR	Dummy variable taking the value 1 for 1946-1958	0.31;0.47 [0;0;1]
K	*Ad valorem* tax rate on the retail price for snuff. Source: Trolle (1965).	0.41; 0.12 [0.25;0.38;0.60]
K^C	*Ad valorem* tax rate on the retail price for cigarettes. Source: Trolle (1965).	0.52;0.15 [0.30,0.53;0.72]
W^1	Dark tobacco price per kilo. Much of the tobacco in snuff is dark air-cured ("types" 35-37) and for 1930-1959 I use the U.S. annual average price (Table 91). For the years 1916-1929, only the price of light flue-cured ("type 11", North Carolina, Table 81) is available and it is multiplied with a factor of 0.51, which was ratio of the average price of types 35-37 to that of type 11 for the period 1930-1940. Prices are quoted in US dollars per lbs and are converted to Swedish kronor using an average annual exchange rate provided by The Swedish Riksbank. Source: http://www.ers.usda.gov/data/sdp/view.asp?f=specialty/94012/)	0.71;0.29 [0.22;0.60;1.31]
W^{1C}	Light tobacco price per kilo. Light flue-cured ("type 11" North Carolina) is used for cigarettes. Source: http://www.ers.usda.gov/data/sdp/view.asp?f=specialty/94012/.	1.34;0.46 [0.49;1.25;2.44]
W^2	Unit tax per kilo of snuff. Source: Trolle (1965).	0.41; 0.29 [0;0.39;1.15]
W^{2C}	Unit tax per 20 cigarettes of medium-size. Source: Trolle (1965).	0.05;0.08 [0;0.02;0.28]
W^3	Hourly wage for workers in food, drinks and tobacco industries. Source: Statistisk Årsbok.	0.76;0.21 [0.34;0.73;1.20]
L	Labor cost per kilo. Obtained as hourly wage times productivity per hour. Productivity is number of workers in snuff production, N, (Trolle, 1965) times number of hours per worker, h, divided with total production, Q^{TOT}. Number of hours per worker is set to 2500 per year in 1916 and falling with 20 hours per year thereafter. $L= W^3\times N\times h/ Q^{TOT}$.	0.05;0.01 [0.03;0.05;0.07]
S	Compensation to retailer per kilo. Obtained as retailer's average margin, s, set by the Swedish Tobacco Monopoly (Trolle, 1965), times the retail price. $S=s\times P$	0.37;0.03 [0.31;0.37;0.46]
D	Distribution cost per kilo. Percent of the STM's overall revenue net of taxes and compensation to retailer, d, (Trolle, 1965) times retail price. $D= d\times P\times(1-K-s)-W^2$)	0.05;0.01 [0.03;0.05;0.08]
MC	Marginal cost per kilo of snuff (direct calculation). $MC= 0.45\times W^1 + W^2 + L + S + D$	1.22;0.38 [0.62;1.12;2.19]
CPI	Consumer price index with base year 1914. Source: SCB Statistiska meddelanden PR 15 SM 0301, Konsumentprisindex 1830–2002.	224;72 [151;231;391]

A) All nominal prices have been deflated by the Consumer Price Index (CPI for 1914 =100).

TABLE 2. DIRECT CALCULATION OF MARGINAL COST AND PRICE-COST MARGIN IN 1925 AND 1950

	1925	1950
Retail price: P	2.65	4.47
Ad valorem tax rate on retail price: K	0.33	0.60
Retail price net of *ad valorem* tax: $P^P = (1 - K)\times P$	1.77	1.79
Tobacco cost: $0.45\times W^1$	0.19	0.48
Unit tax: W^2	0.28	0.39
Labor cost: $L= W^3\times N\times h/ Q$	0.05	0.06
Seller's compensation in percent of retail price: s	0.13	0.09
Seller's compensation: $S= s\times P$	0.35	0.40
Distribution cost in percent of revenue net of taxes and retail margin: d	0.051	0.043
Distribution cost: $D= d\times ((1-K-s)- W^2)\times P$	0.10	0.11
Marginal cost: $MC= 0.45\times W^1 + W^2 +L+S+D$	0.98	1.44
Marginal cost – tobacco cost – unit tax: $MC-0.45\times W^1 - W^2$	0.50	0.57
Absolute margin: $P^P - MC$	0.79	0.35
Price – cost margin: $(P^P - MC)/ P^P$	0.44	0.20

TABLE 3. ESTIMATES OF DEMAND EQUATION (7).

	GMM (1)	LS (2)	2SLS (3)	GMM (4)	GMM (5)
DEMAND					
PRICE SNUFF	-0.292***	-0.167**	-0.316**	-1.287***	-0.541***
	[0.064]	[0.069]	[0.141]	[0.123]	[0.190]
PRICE SNUFF LEADED					0.146
					[0.129]
PRICE CIGARETTES	0.358	0.014	0.398	3.437**	0.866*
	[0.233]	[0.159]	[0.436]	[1.671]	[0.456]
QUANTITY LAGGED	0.710***	0.784***	0.710***		0.737***
	[0.058]	[0.073]	[0.097]		[0.076]
GDP/CAP	-1.086***	-0.957**	-1.137**	-3.773***	-0.846**
	[0.283]	[0.413]	[0.461]	[0.617]	[0.415]
POSTWAR	0.365***	0.315***	0.379***	0.853 ***	0.532***
	[0.109]	[0.109]	[0.127]	[0.188]	[0.153]
CONSTANT	1.833***	1.391***	1.925***	6.373***	1.720***
	[0.399]	[0.459]	[0.651]	[0.419]	[0.514]
AVERAGE OWN-PRICE ELASTICITY					
SHORT-RUN	0.61	0.35	0.64	2.67	XXX
LONG-RUN	2.10	1.61	2.23	2.67	XXX
AVERAGE CROSS-PRICE ELASTICITY	0.12	0.00	0.13	1.14	0.12
R-SQUARE	0.985	0.989	0.986	0.886	0.982
DURBIN-WATSON	1.390	1.210	1.205	0.978	1.603
J-STATISTIC	0.174			0.115	0.170
TEST OF OVERID. RESTR.	0.290			0.564	0.209
OBSERVATIONS	42	42	42	42	42
YEARS	1917-1958	1917-1958	1917-1958	1917-1958	1917-1958
INSTRUMENTS	A1		A1	A1	A2

ESTIMATES BY TSP 4.5. [STANDARD ERRORS] SIGNIFICANCE LEVELS: * = 10 % , ** = 5 % AND *** = 1 %

A1) INSTRUMENTS: C, P^C, Q(-1), GDPCAP, POSTWAR, K, K^C, W^1, W^{1C}, W^2, W^{2C} ,W^3

A2) INSTRUMENTS: C, P^C, Q(-1), GDPCAP, POSTWAR, K, K^C, W^1, W^{1C}, W^2, W^{2C} ,W^3, W^2(1),K(1)

GMM WEIGHTING MATRIX IS ROBUST TO HETEROSKEDASTICY AND AUTOCORRELATION

(KERNEL: BARTLETT. BANDWIDTH: 2)

TABLE 4. ESTIMATES OF DEMAND FUNCTION (7) AND EULER EQUATION (11).

	GMM (1)	GMM (2)	GMM (2)
DEMAND PARAMETERS			
PRICE SNUFF	-0.186***	≡-0.292	-0.180*
	[0.028]		[0.103]
PRICE CIGARETTES	0.131	≡0.358	0.071
	[0.141]		[0.339]
LAGGED QUANTITY	0.814***	≡0.710	0.906***
	[0.036]		[0.049]
GDP/CAP	-0.686***	≡-1.086	-0.195
	[0.283]		[0.278]
POSTWAR	0.365**	≡0.365	0.057
	[0.185]		[0.048]
CONSTANT	1.174***	≡1.833	0.867**
	[0.228]		[0.445]
AVERAGE OWN-PRICE ELASTICITY			
SHORT-RUN	0.39		0.38
LONG-RUN	2.08		4.01
AVERAGE CROSS-PRICE ELASTICITY	0.04		0.03
EULER PARAMETERS			
UNIT TAX	0.975***	0.918***	≡1.000
	[0.036]	[0.101]	
TOBACCO	0.693***	0.355***	≡0.450
	[0.101]	[0.116]	
CONSTANT	0.634***	0.938***	≡0.470
	[0.135]	[0.192]	
DELTA	1.211***	1.427***	≡1.000
	[0.047]	[0.034]	
DURBIN-WATSON DEMAND	1.15		
DURBIN-WATSON EULER	2.08	1.53	2.08
J-STATISTIC	0.249	0.217	0.165
TEST OF OVERID. RESTR.	0.841	0.521	0.541
OBSERVATIONS	42	42	42
YEARS	1917-1958	1917-1958	1917-1958
INSTRUMENTS DEMAND	A		
INSTRUMENTS EULER	B	B	B

ESTIMATES BY TSP 4.5. [STANDARD ERRORS] SIGNIFICANCE LEVELS: * = 10 % , ** = 5 % AND *** = 1 %

A) INSTRUMENTS: C, P^C, Q(-1), GDPCAP, POSTWAR, K, K^C, W^1, W^{1C}, W^2, W^{2C} ,W^3

B) INSTRUMENTS: C, P^C, Q(-1), GDPCAP, POSTWAR, K, K^C, W^1, W^{1C}, W^2, W^{2C} ,W^3, K(+1), W^2 (+1)

GMM WEIGHTING MATRIX IS ROBUST TO HETEROSKEDASTICY AND AUTOCORRELATION

(KERNEL: BARTLETT. BANDWIDTH: 2)

Figure 1. Approximation of marginal cost using prior information (MC) and its components

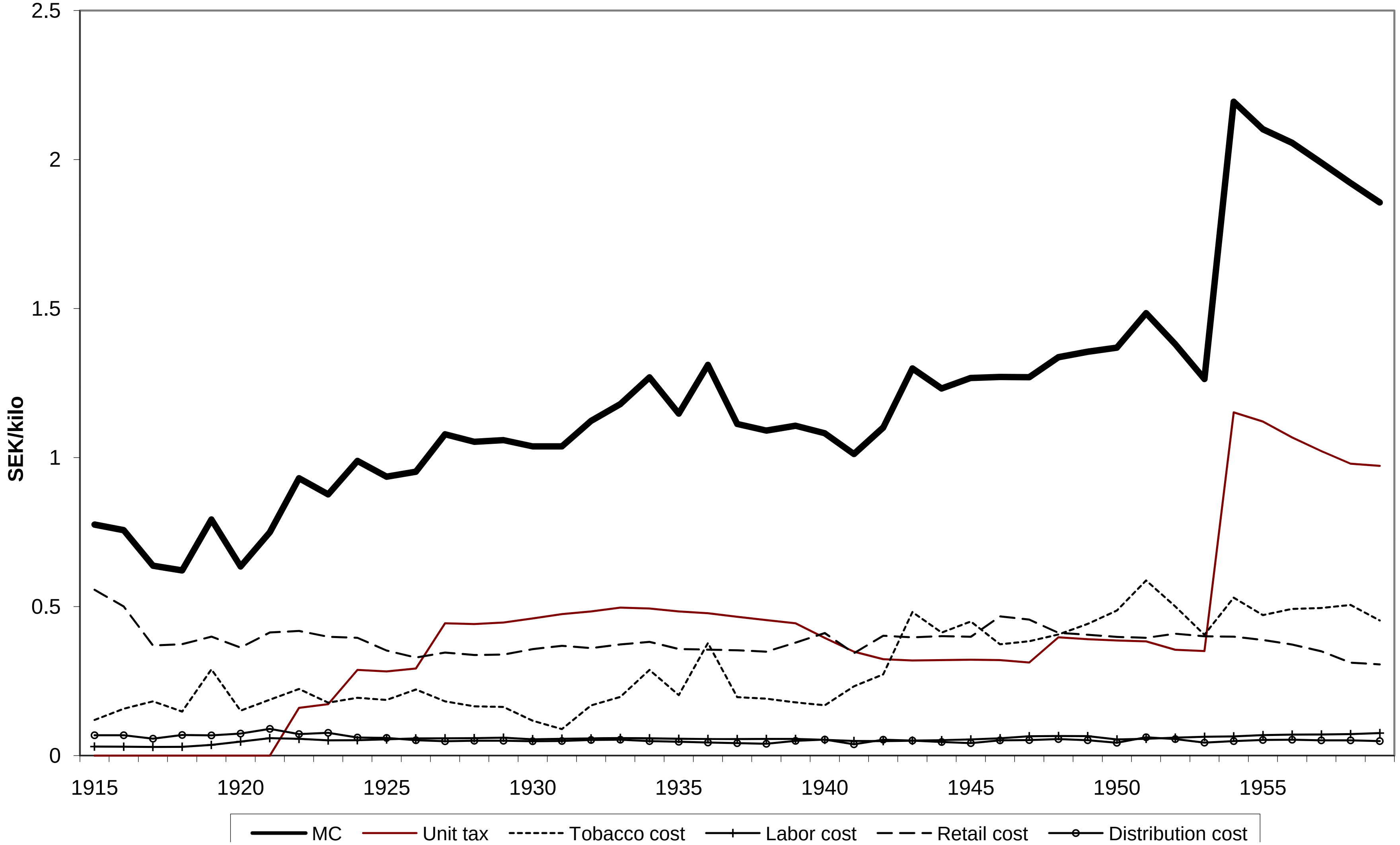

Figure 2. Prices, approximate marginal cost, and margins

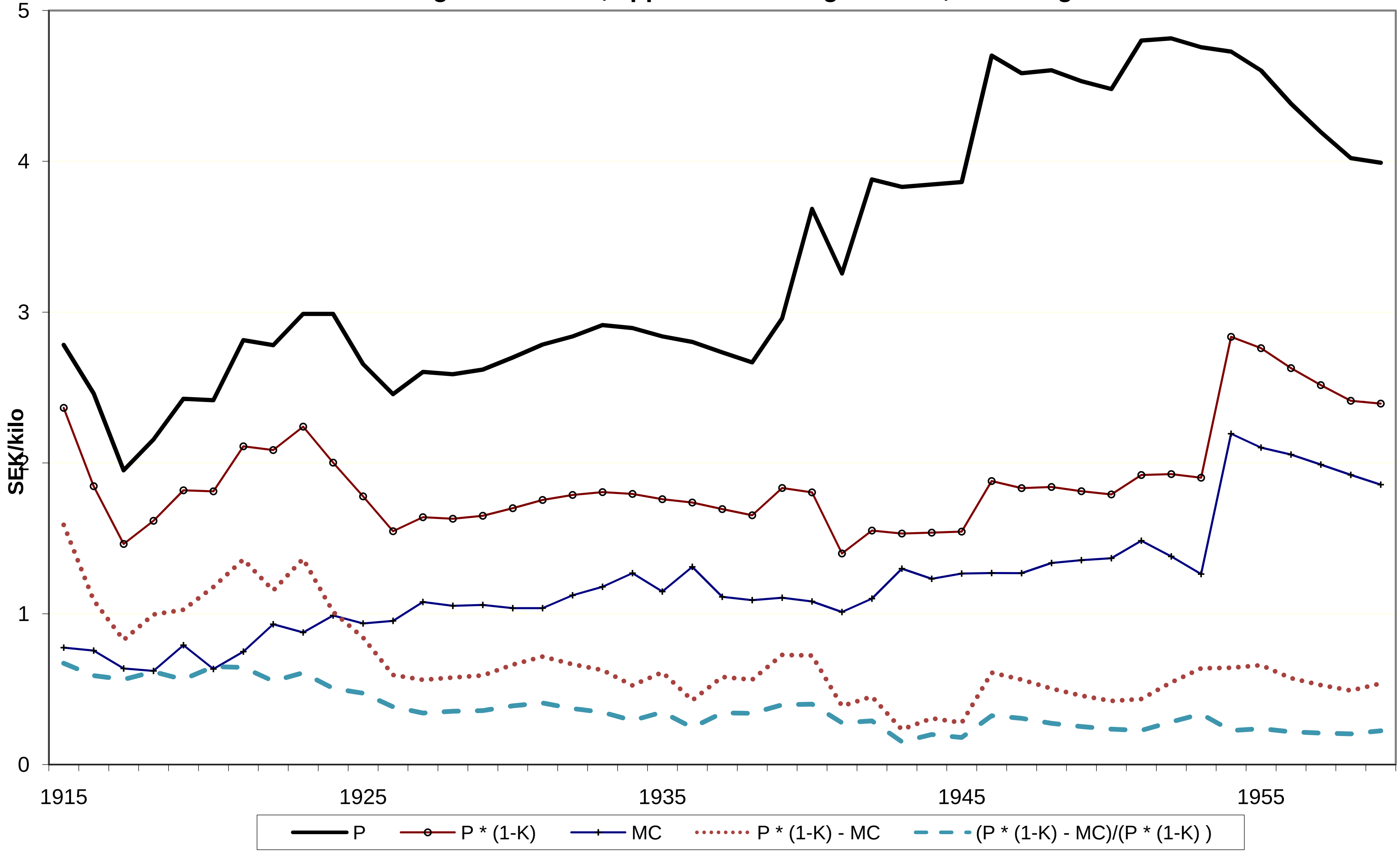

Figure 3. Estimated demand curves for 1935

Actual P=2.84 and Q=2.09 indicated with " • "

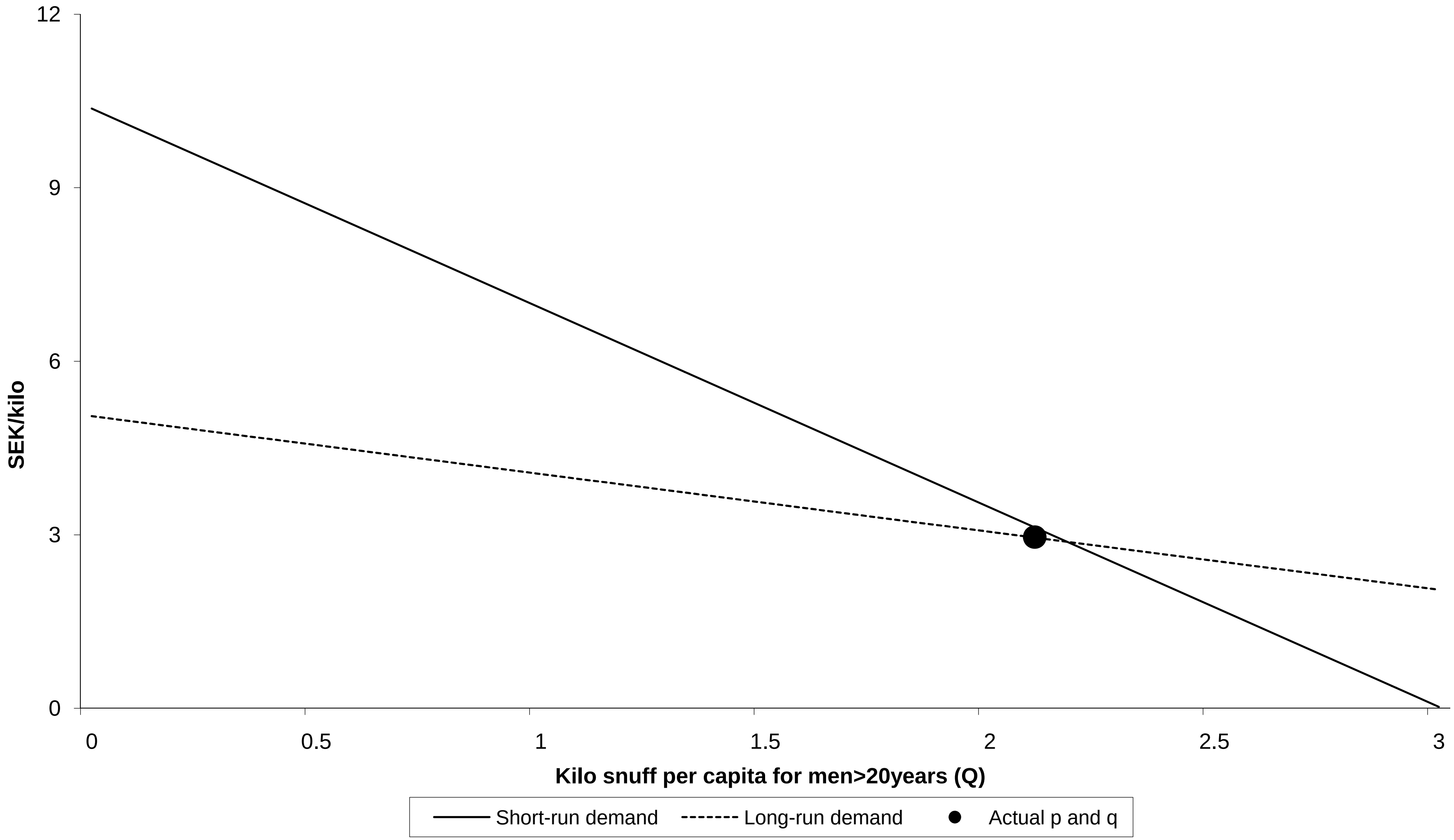

Figure 4. Demand in 1936 as a Function of Price in 1935

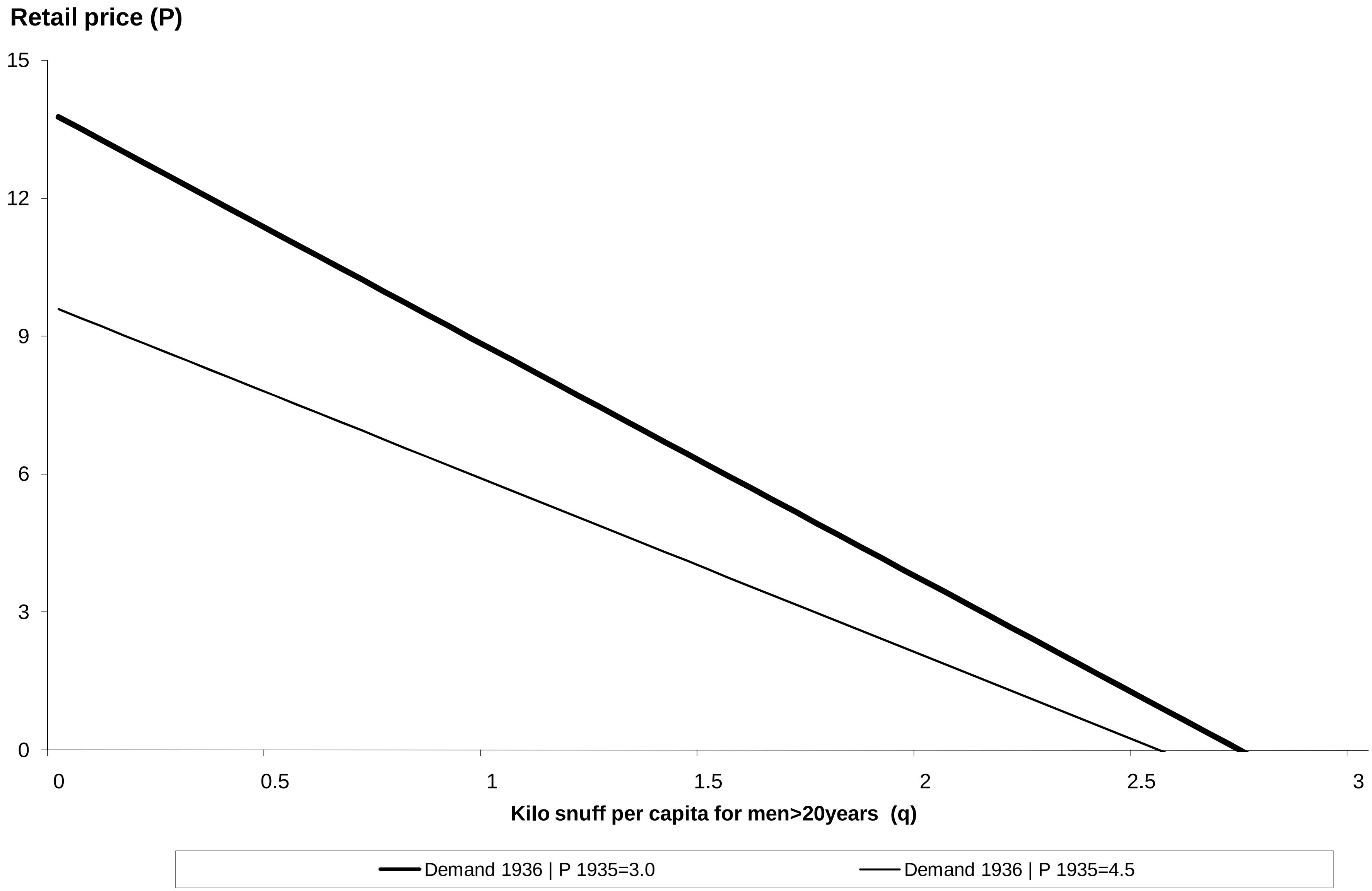

Figure 5. Marginal cost: Calculated (MC) versus estimated (BW)

Figure 6. Actual, optimal, and myopic prices

Figure 7. Situation for Swedish Tobacco Monopoly in 1935
(In 1935, P=2.84, Q=2.09, K=0.38, BW=1.25)