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Estimating Tax Incidence, Market Power and Market Conduct: The European Cigarette Industry

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**ESTIMATING TAX INCIDENCE, MARKET POWER AND MARKET CONDUCT:
THE EUROPEAN CIGARETTE INDUSTRY**

Sophia Delipalla and Owen O'Donnell

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Abstract

Recent theoretical work has shown that the incidence of ad valorem and specific taxes may differ and each may be over or under-shifted onto consumers in the presence of imperfect competition. These results are used to derive a method of estimating market power and conduct. An application is made to the European cigarette industry. Previous empirical comparison of the price effects of ad valorem and specific taxes is limited. For a group of countries with broadly similar cigarette industries, there is evidence of undershifting of both taxes, with the specific tax having a significantly greater impact on price. The extremes of both perfect competition and monopoly can be rejected. Behaviour is no less competitive than the equivalent of Cournot.

JEL Classification: H22, L13, L66

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ESTIMATING TAX INCIDENCE, MARKET POWER AND MARKET CONDUCT: THE EUROPEAN CIGARETTE INDUSTRY

1. Introduction

Tax incidence is a fundamental issue in Public Economics. Identification of market power and measurement of the degree of competition are amongst the most important issues in Industrial Organisation. The taxation of cigarettes has been used to learn about each of these separately. (See Barzel, 1976; Johnson, 1978; Sumner and Ward, 1981 on tax incidence. See Sumner, 1981; Bulow and Pfleiderer, 1983; Sullivan, 1985; Ashenfelter and Sullivan, 1987 on market power and conduct.) In this paper, cigarette taxation is used to examine both sets of issues. One aim is to test the predictions of recent developments in the theory of commodity taxation under imperfect competition (Delipalla and Keen, 1992). The second aim is to develop the literature on the estimation of market power and conduct by proposing a reduced form method which provides point estimates of the price-cost mark-up and the numbers equivalent of firms. This extends a result of Sullivan (1985), who was only able to identify a lower bound for the latter parameter. In this application, the method involves comparing the comparative static effects of specific and ad valorem commodity taxes on price and quantity. However, it will work whenever a variable which shifts the cost function and another which pivots the demand curve can be observed.

Recent theoretical work on tax incidence has shown that commodity taxes may be over- or under-shifted onto consumers in the presence of imperfect competition (Seade, 1985; Stern, 1987). Moreover, the incidence of ad valorem and specific taxes may differ, with the price effect of the former never exceeding that of the latter (Delipalla and Keen, 1992; Skeath and Trandel, 1994). Prior to the imperfect competition model, consideration of the relative price effects of ad valorem and specific taxes focussed on their impact on quality in competitive

markets (c.f. Barzel, 1976; Kay and Keen, 1983, 1991). The ranking of the relative price effects in this environment is consistent with that generated by the oligopoly model. When quality is measured in terms of some untaxed characteristic, a specific tax may lead to an upgrading in quality. Since the increase in quality *per se* tends to raise price, the actual price increase may exceed the (specific) tax increase. An ad valorem tax bears on all commodity characteristics whose value is reflected in consumer price, providing a disincentive to improve quality. Note that ad valorem taxation has a “multiplier effect”, that is, to increase producer price by 1, consumer price has to increase by $1/(1-tv) > 1$ (tv is the ad valorem tax rate). Thus, when the ad valorem tax increases, it is likely to lead to a reduction in quality and, consequently, a price rise lower than the amount of the tax increase.¹

Empirical comparison of the price effects of specific and ad valorem taxes is limited.² Barzel (1976) estimated price effects by exploiting state variation in cigarette taxes in the US. No state employed both taxes simultaneously and only one state used an ad valorem tax. A differential effect of the two types of taxes was tested by examining the significance of an interaction between the level of tax and a dummy indicating whether the tax was ad valorem. He found overshifting of the specific tax and could not reject full shifting of the ad valorem. He attributed the different effects of the two types of taxes to quality responses, the consistency of this result with imperfect competition not yet having been recognised. Johnson (1978) generalises Barzel’s specification by allowing state specific effects, as well as time effects, and finds overshifting of the specific tax and undershifting of the ad valorem. The

¹ Cremer and Thisse (1994), in a model of vertical product differentiation with two firms where each produces a variant of a differentiated commodity, show that an increase in ad valorem taxation can actually reduce the consumer price. Their explanation is that ad valorem taxation reduces the quality of both variants, narrows the quality gap and intensifies price competition.

² In fact, empirical work on commodity tax incidence, in general, is sparse (rare examples are Besley and Rosen, 1994, and Poterba, 1996).

result is interpreted as providing further support for the quality model. Sumner and Ward (1981) question this interpretation on the grounds of implausibility. They ask what is the nature of the quality change which is made to the product in response to a tax change and point out that manufacturers do not produce a different product for the one state levying the ad valorem tax. An alternative explanation is offered for the apparent overshifting - prices may be raised at the time of tax increases not only in response to the tax but also to compensate for accumulated minor cost increases. Controlling for this backlogged price effect, Sumner and Ward find undershifting of both taxes and no significant difference between the two. Their suggested explanation for undershifting is interstate competition. Baltagi and Levin (1986) model cross-border shopping explicitly. They use the lowest price of cigarettes in a neighbouring state to control for cross-state substitution and find a small but significant effect.³ All these studies test Barzel's hypothesis indirectly by looking at the effect of taxes on cigarette prices. Sobel and Garrett (1997) provide support for Barzel's theory through a more direct test, using data on the relative market shares of premium- and generic-brand cigarettes.⁴

Baker and Brechling (1992) look at the effect of excise duty changes on prices in the UK. Their findings suggest that for beer, spirits and petrol, changes in the specific tax are fully reflected in changes in prices. For tobacco and wine, they find undershifting and overshifting respectively. Full shifting of the ad valorem tax can never be rejected. However, as the authors acknowledge, there are only two changes in the ad valorem rate over the data period, making

³ Coats (1995) estimates cross-border effects of state cigarette taxes by looking at the response of state cigarette sales to state cigarette taxes. Barnett *et al.* (1995) compare the effects of federal and state taxes. Simulation results show that an increase in federal tax results in a greater increase in price than does the same change in the average state and local tax. A possible explanation is cross-border shopping. Another explanation is that manufacturers use federal tax increases as a signalling device to co-ordinate a series of price increases (c.f. Harris, 1987).

⁴ Their findings, although supportive of Barzel's theory, do not necessarily show that it was the quality effects that Barzel captured in his empirical study.

it difficult to have confidence in the robustness of the estimated incidence of this tax and to compare it with that of the specific tax. Such lack of variation in the data, particularly with respect to the ad valorem rate, is a failure from which all previous attempts to estimate the relative incidence of specific and ad valorem taxes have suffered. We avoid this limitation by using data from the EU, where all member states levy both a VAT and an excise duty on tobacco, with the excise duty consisting of both a specific and an ad valorem element.

The new empirical industrial organisation (N.E.I.O.) literature is concerned with testing for market power and estimating the degree of both market power and competition without using accounting data on cost and/or profit (for surveys, see Bresnahan, 1989; Carlton and Perloff, 1994; Geroski, 1988). A distinction can be made between structural and reduced form approaches to the problem (Hyde and Perloff, 1995). The former is based mainly on the conjectural variations model and involves estimating a structural market demand function simultaneously with supply relation(s). Identification of the degree of market power and conduct is achieved through comparative statics with respect to some variable which pivots the demand curve (Bresnahan, 1982; Lau, 1982). The advantage of the structural approach is its power. Not only can market power be tested but estimates can be made of the price-cost mark-up and the degree of competition within the industry. There are four main disadvantages. First, data must be available on price, output, input prices and demand and cost shifters. Second, misspecification of the structural demand and/or cost function will bias the estimates, and so the tests, of market power/conduct. Third, when using industry level data, the supply relation estimated does not correspond to the first order conditions unless firms are homogeneous. Otherwise, the supply relation is, in part, ad hoc and the parameters must be interpreted as industry averages (Bresnahan, 1989, p.1030). Finally, the conjectural variations approach is vulnerable to theoretical criticism. Given this, Bresnahan (1989) claims an ‘as-if’ interpretation of the estimated conduct parameter - it indicates behaviour is as competitive ‘as-

if firms held certain conjectures. Corts (1998) demonstrates this argument is valid only under certain conditions.⁵

Tests of market power which do not involve estimation of structural demand and supply relations avoid the above mentioned problems at the cost of losing power with respect to the hypotheses which can be tested and the parameters which can be estimated. Hall (1988) provides a joint test of the hypotheses of perfect competition and constant returns to scale. The joint nature of the test impedes interpretation somewhat. Estimates of the degree of market power and market conduct can be obtained only by imposing further restrictions and with additional information available (Shapiro, 1987). Panzar and Rosse (1987) are able to test the extreme cases of market conduct - perfect competition and monopoly - but do not obtain an estimate of the degree of market power or competition. Sumner (1981) claimed the impact of a unit tax in a reduced form price equation identified the industry average mark-up and the firm level elasticity. Bulow and Pfleiderer (1983) demonstrated this claim was valid only for special cases of the demand function.⁶ Sullivan (1985) linked the method of Panzar and Rosse (op cit) with that of Sumner (op cit) and Bulow and Pfleiderer (op cit) and showed that the effects of a unit tax in reduced forms for price and quantity can be used to identify a lower bound on the numbers equivalent of firms. This allows testing of the hypothesis of monopoly, but not competition.⁷

We take this literature one step further by proposing a reduced form method which allows identification of the price-cost mark-up and the numbers equivalent of firms. The

⁵ Inference of market power from the estimated conduct parameter is valid only if the behaviour underlying the observed equilibrium is identical at the margin, and not just on the average, to a conjectural variations game.

⁶ Genesove and Mullin (1998) also note that identifying the conduct parameter through the responsiveness of price to cost alone is essentially dependent upon the demand specification (p.371).

⁷ Ashenfelter and Sullivan (1987) give a non-parametric implementation of the Sullivan (1985) method.

hypothesis of market power can therefore be tested and the degree of market power and competition within the industry estimated. The method works through comparing the price effects of specific and ad valorem commodity taxes. Non-equivalence is an indication of market power. The industry average price-cost mark-up is identified through taking the ratio of the price effects of the two taxes. Having estimated the mark-up, a parameter reflecting the conduct of the industry (i.e. the numbers equivalent of firms) is identified if the price elasticity of market demand is known or can be estimated. The method proposed combines the best of the structural and reduced form approaches described above - it is powerful, yet parsimonious with respect to data requirements and assumptions imposed. The methodology is applicable to other industries with both specific and ad valorem taxes or, more generally, where there is an observable variable which shifts unit costs and another which pivots the demand curve.

The European cigarette industry, being highly concentrated, provides an appropriate context for trying out our method of estimating market power and to test the recent developments in the theory of tax incidence allowing for imperfect competition. The estimates are not only of interest in relation to the academic economics literature but also as a source of information for a variety of policy discussions. There has been a long running debate in Europe over the harmonisation of cigarette taxes. Although all EU countries tax cigarettes heavily, there is a split between those favouring ad valorem taxation - roughly, the south - and those with a more balanced tax structure - roughly, the north. These differences have impeded fiscal harmonisation. Evidence on the relative effects of the two taxes might help to resolve the debate. The taxation of cigarettes is motivated, in part, by public health concerns. Evaluations of the effectiveness of taxation as an anti-smoking instrument have concentrated on the estimation of price elasticities of demand, adopting the assumption that taxes are fully shifted onto consumers (c.f. Chaloupka and Warner, 1998). Tests of the validity of this assumption are important in assessing the health policy role, and the distributional effects, of

cigarette taxation. The Tobacco Resolution proposed in the U.S. and the high profile legal actions taken against cigarette manufacturers there have focussed attention on the industry. Given the scale of the tax increases contemplated in the Resolution, knowledge of the degree of shifting of taxes onto prices and the conduct of the industry would be crucial in predicting the consequences of such legislation (Bulow and Klemperer, 1998).

The next section presents the theoretical framework for analysing how ad valorem and specific taxes affect prices. The comparative statics are used to develop the new reduced form method of identifying the price-cost mark-up and the numbers equivalent of firms. In section 3, we describe the European cigarette industry. The data are discussed in section 4 and the results presented in section 5. Section 6 concludes.

2. Market power and the relative incidence of ad valorem and specific taxation

We consider the conjectural variations model, as in Delipalla and Keen (op. cit.), only we look at the non-symmetric equilibrium. In an industry with n firms, the after-tax profit earned by firm i is

$$\pi^i = [(1 - tv)P(X) - ts]x^i - c(x^i), \quad (1)$$

where P is the consumer price, X is the industry output, x^i is the firm's output, $c(x^i)$ is the firm's total cost of producing the given level of output and ts and tv are the specific and ad valorem tax rates respectively. The strategic interaction between firms is captured by

$\frac{dX}{dx^i} = \lambda^i \in [0, n]$. With $\lambda^i = 0$, conjectures are "competitive"; $\lambda^i = 1$ corresponds to Cournot

conjectures and $\lambda^i = n$ to tacit collusion. The first-order condition for profit maximisation is given by

$$(1 - tv)[P(X) + \lambda^i P_X x^i] - c_{x^i} - ts = 0, \quad (2)$$

with subscripts indicating derivatives. Dividing (2) by λ^i and summing over i , yields

$$(1 - tv)P \left[\sum \frac{1}{\lambda^i} + \frac{P_X}{P} X \right] - \sum \frac{1}{\lambda^i} c_{x^i} - ts \sum \frac{1}{\lambda^i} = 0. \quad (3)$$

Solving (3) for P and using $e = -X_P P / X$,

$$P = \frac{1}{1 - \frac{1}{e \sum \frac{1}{\lambda^i}}} \phi, \quad (4)$$

where

$$\phi = \frac{1}{1 - tv} \left(\frac{\sum \frac{1}{\lambda^i} c_{x^i}}{\sum \frac{1}{\lambda^i}} + ts \right) \quad (5)$$

Comparative statics show that taxes affect price as

$$\frac{dP}{dts} = \frac{1}{(1 - tv)} \frac{\sum \frac{1}{\lambda^i}}{[\sum \frac{1}{\lambda^i} + 1 + A - E]} \quad (6)$$

and

$$\frac{dP}{d tv} = \phi \frac{dP}{dts}, \quad (7)$$

where $A = \frac{\sum \frac{1}{\lambda_i} c_{x^i x^i}}{(1 - tv)nP_X}$ and $E = -P_{XX} X / P_X$ denotes the elasticity of the slope of the inverse

demand function. Equation (6) is immediate on applying the implicit function theorem to (3);

(7) follows similarly on noting from (3) that

$$P \sum \frac{1}{\lambda^i} + P_X X = \phi \sum \frac{1}{\lambda^i}. \quad (8)$$

Comparing (6) and (7), using (4) and denoting $\theta = 1 / (1 - \frac{1}{e \sum \frac{1}{\lambda^i}})$, we get

$$\frac{dP/dts}{dP/Pd\tau} = \theta. \quad (9)$$

That is, the ratio of the marginal effects of the specific and ad valorem tax is equal to θ , the mark-up parameter. Under perfect competition, this parameter is equal to one and the two taxes have equivalent effects on price. However, with imperfect competition (i.e. $\theta > 1$), the price effect of the specific tax exceeds that of the ad valorem by a proportion given by the value of the mark-up.

Since prices are set above marginal cost, an increase in cost due to a change in taxation need not be reflected in an identical increase in price. There is full shifting of a tax onto the consumer if the producer price, $p' = (1 - \tau)P - ts$, is invariant to the level of the tax. Then, the degree of tax shifting is given by

$$\frac{dp'}{dts} = \frac{dP}{dts}(1 - \tau) - 1 \quad (10)$$

and
$$\frac{dp'}{Pd\tau} = \frac{dP}{Pd\tau}(1 - \tau) - 1 \quad (11)$$

Expressions (10) and (11) are less than, equal to and greater than zero with undershifting, full shifting and overshifting respectively. The outcome which emerges depends upon the value of parameters related to the market structure, cost structure and demand elasticity of the industry.⁸ Overshifting of the specific tax is necessary but not sufficient for overshifting of the ad valorem tax.

The realism of an assumption of homogeneous products can obviously be questioned. However, Anderson *et al.* (1997) show the results of Delipalla and Keen (op. cit.) on the

⁸ Perfect competition is sufficient but not necessary for full shifting to occur. For example, in the presence of imperfect competition combined with constant marginal costs and constant elasticity of demand, there will be full shifting of the ad valorem tax (and overshifting of the specific tax).

relative incidence of the two taxes carry over to a model with horizontally differentiated products in Bertrand-Nash oligopoly.⁹

Note that from (4),

$$\sum \frac{1}{\lambda^i} = \frac{1}{e \left(1 - \frac{\phi}{P} \right)} = \frac{1}{e \left(1 - \frac{1}{\theta} \right)} \quad (12)$$

The term on the left-hand-side is the numbers equivalent of firms, which can be estimated provided one has estimates of the two parameters on the right-hand-side - the mark-up (θ) and the price elasticity of demand (e). For the latter, one could use an extraneous estimate. Alternatively, (12) can be rewritten as

$$\sum \frac{1}{\lambda^i} = \frac{1}{\frac{dX / dts}{dP / dts} \left(1 - \frac{dP / P dts}{dP / dts} \right)}. \quad (13)$$

Provided one has data on market quantity, as well as price, the marginal effects of the taxes in reduced form price and quantity functions give an estimate of the degree of competition within the industry, in addition to the mark-up. With both types of taxes, we are able to obtain point estimates of both parameters, whereas Sullivan (1985), with only a specific tax, could only get a lower bound for one of the parameters - the numbers equivalent of firms.

3. The European cigarette industry

The empirical analysis is based on data from the twelve members of the EU prior to its expansion in 1995. The European cigarette industry is characterised by a high degree of concentration. In 1992/93, the top five firms in each country held in excess of 90% of the

⁹ While Anderson *et al.* (1997) relax the homogeneous product assumption, their model is more restrictive than Delipalla and Keen (1992) in respect of the market structures and consumer preferences admitted.

market in every case (see Table 1).¹⁰ A major difference in the nature of the markets across Europe arises from direct state involvement in France, Italy, Spain and Portugal. In these countries, the state has an effective monopoly on the manufacture and distribution of domestic cigarettes and the market is even more concentrated than it is elsewhere. The remainder of the market in these countries, and the vast majority of the market in the other countries, is dominated by a group of American and British multinationals. The exception is Denmark, where a private domestic company (Skandinavisk Tobak) enjoys an almost monopoly position.¹¹ There are also differences in the nature of the product. In the four countries where the state is involved in production, the market is led by domestic brands made from European tobacco. In most of the other countries, Greece being a notable exception for most of the period of our analysis, the American tobacco brands of the multinationals lead the market.

Cigarette prices and taxes for the period of analysis, 1982-97, are summarised in Table 2. The prices refer to the highest selling category, defined by price (i.e. the most popular price category (MPPC)), in each country. There are large differences in gross prices, with the lowest prices being in southern Europe. With two exceptions, the real gross price of cigarettes increased over the period.¹² In a number of cases, the increase was substantial. The heavy burden of taxation is indicated by the large differences between gross and net prices. The smaller variance across countries in net prices indicates tax differences are, to an extent, responsible for the differences in gross prices. The tax burden has increased in a number of countries and there is now a degree of consistency with respect to the level of taxation. This is

¹⁰ The figure shown in the table for Greece is less than 90% but, as noted, this refers to the share held by domestic producers only. It is likely that including MNCs would push the figure above 90%.

¹¹ Even in this case, an Anglo-American multinational has a one third share in the company.

¹² The fall in price indicated for Greece is apparent, rather than real, reflecting depreciation of the currency.

the result of EU legislation, which now requires that the total tax burden be at least 70 percent of the gross price.

The lack of progress in harmonising the structure of cigarette taxation is apparent from the final two columns of Table 2. According to the theory discussed in section 2, specific taxation leads to higher prices, for a given tax revenue. It is understandable that there is greater tolerance of this type of taxation in some of the countries of northern Europe, where smoking prevention movements are more firmly established.¹³ In southern countries, smoking prevention - although growing - is a politically sensitive issue because of the cultural and economic importance of tobacco. These countries prefer ad valorem taxation since, through the multiplier effect, it increases the price advantage to the local brands, often made from domestically grown tobacco, relative to those of the multinationals. Theory also predicts specific taxation is more advantageous for profit relative to ad valorem (Delipalla and Keen, 1992). The multinational companies predominant in the north of Europe would therefore be expected to lobby for this type of taxation. On the other hand, state producers might be more interested in tax revenue than profit and would be expected to favour ad valorem taxation. It is striking that in Portugal, where there is effectively a state monopoly, the burden of taxation is among the highest in the community, yet gross prices are among the lowest.

The differences in the preferred structure of cigarette taxation have impeded agreement on harmonisation. The first EU directive issued in 1972 (Directive 72/464/EEC) instructed all member states to introduce a mixed tax structure. The specific tax should be not less than 5% and not higher than 75% of the total excise duty. The directive was clearly in favour of predominantly ad valorem taxation; at that time the majority of EC members had an entirely

¹³ Moreover, Cnossen (1992) argues that specific taxation is a better instrument to internalise the “external costs” that smoking imposes, since it hits the cause of the costs directly and does not tax items that do not contribute to the costs, such as wrappers, or even mitigate the effects of smoking, such as filters.

ad valorem tax structure. Shortly afterwards, Denmark, Ireland and the UK, countries with predominantly specific taxation, joined the Community. A second directive was approved in 1977 (Directive 77/805/EEC) according to which the specific tax should be between 5% and 55% of the total tax burden including the VAT. This second stage was extended five times until 1985, when it was extended indefinitely. After several years of disagreement, in 1992, it was agreed that the overall excise duty should be no less than 57% of the final retail price of the most popular price category (all taxes included), and the VAT should be at least 15% of the final retail price (inclusive of excises). These directives implied a minimum overall tax level on cigarettes of 70% of the retail price. The ratio of specific to total taxation should be the same as in the 1977 Directive. From Table 2, it is apparent that there is a tendency for countries to locate toward either of the extreme bounds on this ratio.

4. Data

We compare the effects of specific and ad valorem taxes on cigarette prices by regressing price data from twelve European countries over sixteen years on corresponding tax data and controls for other determinants of prices (demand and cost conditions). For ten countries, the data cover the period 1982-97; for Spain and Portugal, 1986-97. The data are for prices and taxes in operation at January 1 of each year.¹⁴ The price data are for 1000 cigarettes in the most popular price category (MPPC), which will vary across countries and, potentially, also across time. Variation across countries can be dealt with through country specific effects. Variation across time is more difficult to accommodate since this time effect would not be common across countries. An inference problem would arise if switches in the MPPC were

¹⁴ For two years we do not have data specific to January 1. For 1982 we use May 1 data and for 1995, July 1. This is unlikely to be a significant problem given there is little intra-year variation in the tax and price series. For the period 1982-90, we have quarterly data. Estimates obtained from annual and quarterly data showed little difference.

correlated with tax changes. Various sources have been checked to identify any changes in the MPPC over the sample period. There are two cases of large jumps in the price of the MPPC which appear, at least in part, to arise from a switch of the leading price category - France 1988-89 and Greece 1993-94. In the former case, the problem has been dealt with by specifying different group effects for the periods 1982-88 and 1989-97. In the case of Greece, there are insufficient data points after the switch to allow a separate group effect for this period and so the Greek series has been truncated at 1993.

The specific tax is the monetary amount levied on 1000 cigarettes and the ad valorem rate is the sum of the ad valorem excise duty and VAT expressed as a percentage of the tax inclusive retail price. Sources for all of the data are given in the Appendix. As a control for cost variation, we include labour costs per worker in the manufacturing sector of the tobacco industry.^{15,16} As with all of the control variables, the data are for the year preceding the January 1 date to which the price and tax data refer. GDP per capita is included as a determinant of the level and price elasticity of demand. With the exception of GDP per capita, which is denominated in purchasing power standards, all monetary variables are converted to ECUs. The ECU exchange rate is included, as an additional control, to avoid spurious correlation arising from depreciation or appreciation of a currency. All monetary denominated variables were deflated to 1985 prices using country specific consumer price indices.

¹⁵ For France and Luxembourg data specific to the tobacco industry were not available. Labour costs per worker across the whole of manufacturing industry were used instead. The appropriate data is absent for Ireland before 1985. For this period, data specific to food, tobacco and alcohol manufacturing are used. For many of the countries, labour cost data were not available for 1996. We used a forecast based upon an assumption of no real change in labour costs per worker between 1995 and 1996.

¹⁶ Unit labour costs in tobacco manufacturing were used as an alternative cost control but labour costs per worker were found superior with respect to significance and diagnostic tests. As a control for capital costs, real long term interest rates were included initially but were found not to be significant and could be excluded without affecting the remaining coefficients.

5. Results

Differences in the nature of the cigarette industry across Europe were discussed in section 3. While some of these differences can be dealt with in estimation through the inclusion of country effects, others affect not only price levels but the tax responsiveness of prices. Indeed, according to the theoretical results, differences in market power and conduct should be reflected in tax-price relationships. In the context of a linear in levels specification estimated by OLS with country specific intercepts, the restriction of homogeneity in slope coefficients is decisively rejected [$F=62.30$ ($p=0.0000$)]. We therefore look for sub-sets of countries across which this restriction has greater validity.

Country specific tax shifting parameters, calculated from individual country price regressions, are presented in Table 3.¹⁷ Given small sample sizes, these estimates cannot be expected to be particularly accurate. However, they are useful in identifying important differences in tax-price relationships across countries. In most cases, the estimates suggest undershifting of the ad valorem tax. In three countries (Denmark, the Netherlands and Portugal), this undershifting is significant. In only one case (Italy) there is evidence of significant overshifting of the ad valorem tax. In contrast, six countries show significant overshifting of the specific tax, with only one (Netherlands) indicating significant undershifting. The theoretical prediction that the price effect of the specific tax exceeds that of the ad valorem is confirmed in all but two cases (Germany and UK). In neither of these two theoretically inconsistent cases does the difference between the tax effects reach statistical significance. On the other hand, there are six cases in which the specific tax has a significantly greater impact on price than the ad valorem.

¹⁷ See notes to Table 3 for a description of the estimation procedure. Regression coefficients are available from the authors.

Estimates of the overshifting of the specific tax in France and Luxembourg are very large and result in extremely large ratios of specific to ad valorem effects. Such results probably reflect peculiarities in the market for cigarettes in each of these countries. In France, the market is led by a state producer, whereas cross-border shopping has a very large impact on the market in Luxembourg.¹⁸ These features might be expected to result in complex relationships between tax and price and to render the theoretical model we are interested in testing inapplicable. It is noticeable that the ratio of the two tax effects is also large for two (Portugal and Spain) of the remaining countries in which the state has monopoly control of domestic production. This ratio is also large in the case of Greece, where domestic manufacturers, using domestically grown tobacco, have a large share of the market. Italy, the final country with state production, is distinguished by estimates of a large degree of overshifting of both taxes.

As might be anticipated, results from individual country regressions suggest state production (France, Italy, Portugal and Spain), production from domestically grown tobacco (Greece) and a very large amount of cross-border shopping (Luxembourg) affect tax-price relationships. We therefore concentrate on estimates derived from a group of countries without these features (Belgium, Denmark, Germany, Ireland, Netherlands and UK – Group 1). As illustrated by Table 1, these countries display a degree of homogeneity with respect to market structure. With the exception of Denmark, they are all dominated by a small number of multinationals and there is similarity across the countries in the most popular type of cigarette. The ratio of the tax effects, which according to the imperfect competition model is the mark-up parameter, is estimated to be larger in Denmark than in the others from this group. This might reflect the greater degree of market concentration in this country. In the

¹⁸ Up to 80% of cigarettes sold in Luxembourg are purchased by non-residents (European Bureau for Action on Smoking Prevention, 1995).

interests of efficiency, we choose to include Denmark in the core group countries and comment on the sensitivity of the results to its exclusion. Estimates from pooling the remaining countries (France, Greece, Italy, Luxembourg, Portugal and Spain - Group 2) are also presented. The peculiarities of the markets in these countries make them less interesting from the point of view of testing the model of imperfect competition, however, good estimates of the average degree of tax shifting across these countries are of interest in their own right.

Estimates of price regressions for Group 1 and 2 countries are presented in Table 4. The within groups (WG) estimator is used - Hausman tests reject the random effects specification. Time effects are significant and included for Group 1 but not Group 2. RESET tests favoured a levels specification for Group 1 and a log transformation of all variables for Group 2. Quadratic terms are included where they were found to be significant.¹⁹ All variables take the anticipated signs in each regression, with the exception of the negative wage effect in Group 2. The high R^2 values, while not unusual for this type of data and analysis, might suggest problems of non-stationarity. Given the length of the time series, no formal testing for unit roots is undertaken. However, it is reassuring that, at least for Group 1, estimation in first differences gave very similar results to those presented. The Durbin-Watson values are also reassuring in this respect. A dynamic specification was tried, through the inclusion of a lagged dependent variable, but was not found to be appropriate in either case.

The assumed homogeneity of the slope coefficients is rejected for Group 2 but cannot be rejected at the 1% level of significance for Group 1.²⁰ Similarity in the cigarette industries across Group 1 countries appears to give rise to similar tax-price relationships and justifies pooling of the data across these countries. While the within groups estimator allows for

¹⁹ Interaction effects were not found to be significant.

²⁰ The restriction is rejected at 5% significance for Group 1. Provided variation in the parameters is random, the WG estimator gives consistent estimates of the mean (across country) vector of parameters (Hsiao, 1986, p. 132).

correlation between country fixed effects and the regressors, there remains the potential for endogeneity of the tax variables. For example, the EU rules on the level and structure of cigarette taxation may lead to dependence of the taxes on prices. Countries at, or close to, the lower limit on total taxes as a percentage of the retail price (70%) must raise taxes in response to a price increase. Further, being close to the lower (5%) or upper (55%) threshold for the specific tax as a proportion of total taxes will require a shift in the balance of taxation following certain price movements. Hausman tests, based on comparison between WG and two-stage WG estimates in which the tax variables are instrumented, indicate the null of exogeneity cannot be rejected for either group.²¹ This is perhaps to be expected for the Group 1 countries, given only one (Germany) had a tax burden very close to the 70% threshold. Further, with the exception of Belgium, these countries have a balanced structure of ad valorem and specific taxation. Only price falls, not the more likely price rises, cause problems for such countries attempting to keep within the upper limit on the tax structure ratio. Only two countries (Ireland and UK) were very close to this limit anyway.

Tax incidence, market power and conduct parameters calculated from the coefficients on the tax variables and using sample mean values are presented in Table 5. The estimated parameters differ across the two groups of countries. In Group 1, there is significant undershifting of both types of taxes. A unit increase in tax arising from a change in the ad valorem rate results in an increase in price of 0.72, whereas a unit increase in the specific tax increases price by 0.92. The difference in the price effects is statistically significant. These results are consistent with the theoretical predictions in section 2: under imperfect competition

²¹ Given cigarette taxes are set with some regard to the state of the macroeconomy, the following were selected as instruments: real growth rates of private consumption and GDP, the general government deficit/surplus as a percentage of GDP and the unemployment rate. Given the quadratic specification, following Kelejian (1971), levels, squares and cross-products of all the exogenous variables are used as instruments.

there need not be full-shifting of commodity taxes and a specific tax will have a greater impact on price than an ad valorem. The theory also suggests that the ratio of the price effects of the two taxes is an estimate of the price-cost mark-up (θ). The mark-up is estimated to be 1.28.²² There are no previous estimates available for Europe with which to compare this estimate. Applebaum (1982), following a structural approach, estimates a mark-up of 2.84 in the U.S. tobacco industry.

Since we have no quantity data corresponding to the price data we employ, that is, the MPPC, we use (12), rather than (13), to estimate the numbers equivalent of firms. Point estimates and 95% confidence intervals are given in Table 5 for various values of the price elasticity of demand ($-e$). Estimated competitiveness is lower the higher the assumed value of the price elasticity. The literature provides a wide range of estimates of the latter, with some clustering around a value of -0.4 (Chaloupka and Warner, 1998). At this value, our estimate of the numbers equivalent of firms is 11.41 for Group 1. This lies within the range of estimates of the lower bound on the numbers equivalent of firms in the U.S. cigarette industry calculated by Sullivan (1985). From the figures provided in Table 1, it is apparent that, in general, there are five or six firms operating in each of the markets included in Group 1. At a market price elasticity of -0.4, the 95% confidence interval for the numbers equivalent does not include 6, suggesting firms in these markets are behaving in a manner which is more competitive than the equivalent of Cournot. Assuming higher values for the price elasticity, the equivalent of Cournot behaviour could not be rejected. However, even assuming a unitary price elasticity, the confidence interval does not include 1, allowing rejection of the hypothesis of cartel behaviour.

²² The pattern and statistical significance of the results for Group 1 are not changed if Denmark is excluded. It is reassuring, given the near monopoly supply in Denmark, that this exclusion results in a fall in the estimate of the mark-up.

The results for Group 2 indicate significant overshifting of both taxes. Overshifting of the specific tax is particularly marked - a unit increase in tax is estimated to raise price by more than two. The difference in the price effects of the two taxes is significant at 10% but not 5%. Given the presence of state producers within this group, it might be argued that the results should not be interpreted according to the theory of section 2, which assumes profit maximisation. If such an interpretation is made, the results suggest a mark-up of 1.47. A higher mark-up for this group of countries than for Group 1 is consistent with a priori expectation given knowledge of differences in market structure. The numbers equivalents of firms estimates are smaller than for the first group of countries, suggesting less competitive behaviour. The equivalent of Cournot behaviour could not be rejected for a value of the price elasticity as low as -0.2. Assuming a price elasticity at, or above, -0.6 would not allow rejection of cartel behaviour. While the potential inapplicability of the theoretical model to Group 2 countries must be acknowledged once more, it is interesting that the estimate of low competitiveness is consistent with a priori expectation given the very high concentration in these countries.

6. Conclusions

This paper had three principle aims. First, to test predictions from recent theory of commodity tax incidence in imperfectly competitive markets. Second, to introduce and apply a new method of estimating market power and conduct. Third, to inform policy debates on tax harmonisation in Europe and the use of cigarette taxation as an instrument of health policy.

The results reveal that commodity taxes are not always fully shifted onto consumers. For a group of northern European countries with similar market structures and quality of cigarettes (Group 1), there is evidence of undershifting of both ad valorem and specific taxes, with significant differences between the two. In a remainder group of mainly southern European

countries, there appears to be overshifting of both taxes, with, again, a significantly greater effect of specific taxation. While these results are consistent with the predictions of the imperfect competition model discussed in section 2, quality effects could also be responsible for the specific tax having a larger impact on price than the ad valorem. However, according to Kay and Keen (1991), neither undershifting of both taxes, nor overshifting of both, is a plausible scenario under the quality model. Also, it is difficult to identify changes in quality in these markets, to which undershifting of the ad valorem in Group 1 and overshifting of the specific in Group 2 could be attributed. Imperfect competition is a more persuasive explanation.²³ For Group 1, for which the theoretical model has greater relevance, the results allow rejection of both market extremes - perfect competition and cartel behaviour. More specifically, firms' behaviour in these markets would appear to be no less competitive than the equivalent of Cournot and are probably more competitive than this. If the results from Group 2 are interpreted within the context of the theoretical model, they suggest less competitive behaviour than in Group 1, with the equivalent of Cournot not being rejected and, at perhaps implausibly high price elasticities, cartel behaviour not being rejected.

Our empirical finding that the specific tax has a greater impact on price makes differences in preferences for the form of cigarette taxation across Europe understandable. If northern governments want high prices, to satisfy the health lobby, and high profits, to please the multinationals, specific taxation is the preferred option. Governments in southern Europe are less exposed to these lobbies and favour ad valorem taxation in order to maintain the price advantage to the domestic products. Our empirical confirmation of the differential effect of the two types of tax suggests there will be little progress in harmonising the structure of

²³ Another explanation for the undershifting in Group 1 is cross-border shopping. While this is a growing issue, it unlikely to have been significant for the greater part of the period covered in this analysis. Also the problem is reduced by the exclusion of Luxembourg from this group.

cigarette taxation across Europe, provided governments continue to pursue different objectives. Further, the finding that the effect of a given tax varies across Europe makes harmonisation even less likely.

Estimates of the distributional effects of taxation are typically generated under the assumption that commodity taxes are fully shifted. Our estimates show that this assumption does not always have empirical validity. Under the assumption of full shifting, cigarette taxation has been found to be regressive. Given the overshifting found in the south, concerns, if any, over such regressivity should be intensified. On the other hand, cigarette taxes might not be as regressive as is thought in the north, given evidence of undershifting, particularly of the ad valorem tax. In both cases, the empirical findings suggest a more careful analysis of tax incidence. A similar warning applies to analysts of cigarette taxation as an instrument of health policy.

Appendix - Data sources

The price and tax data are taken from the *Summary of Tax Structures on Cigarettes in E.C. Member States* obtained from the *European Commission (D.G. XXI) Excise Duty Tables* and the *Confederation of European Community Cigarette Manufacturers*.

Total labour costs and employment in the tobacco (manufacturing) industry were supplied by *Eurostat* from their *DEBA* database.

GDP at market prices in current prices and current Purchasing Power Standards per capita were obtained from various Eurostat sources (1982-84 - *Eurostat National Accounts ESA: aggregates 1970-91*, 1985-94 - *Eurostat Yearbook 1996*, 1995-97 - *Eurostat NEWCRONOS Database*). The series was converted to 1985 prices using the Consumer Price Index (CPI).

National CPIs were obtained from *Eurostat's NEWCRONOS database*. Price and specific tax data were deflated using the CPI specific to January each year. Other variables were deflated using the CPI for the appropriate year. In 1997 Eurostat changed from using National CPIs to its new *Harmonised Indices of Consumer Prices* (still country specific but calculated using a common methodology). Price and tax data for January 1 1997 were deflated using this new CPI series.

ECU exchange rates were obtained from *Eurostat's NEWCRONOS database*.

REFERENCES

- Anderson, S.P., A. de Palma and B. Kreider, 1997, Tax incidence in differentiated product oligopoly, *mimeo*, University of Virginia.
- Applebaum, E., 1982, The estimation of the degree of oligopoly power, *Journal of Econometrics*, 19, 287-299.
- Ashenfelter, O. and D. Sullivan, 1987, Nonparametric tests of market structure: An application to the cigarette industry, *The Journal of Industrial Economics*, 35, 4, 483-498.
- Baker, P. and V. Brechling, 1992, The impact of excise duty changes on retail prices in the UK, *Fiscal Studies*, 13, 2, 48-65.
- Baltagi, B.H. and D. Levin, 1986, Estimating dynamic demand for cigarettes using panel data: The effects of bootlegging, taxation and advertising reconsidered, *The Review of Economics and Statistics*, 68, 148-155.
- Barnett, P.G., T.E. Keeler and T-W Hu, 1995, Oligopoly structure and the incidence of cigarette excise taxes, *Journal of Public Economics*, 57, 457-470.
- Barzel, Y., 1976, An alternative approach to the analysis of taxation, *Journal of Political Economy*, 84, 6, 1177-97.
- Besley, T.J. and H.S. Rosen, 1994, Sales taxes and prices: An empirical analysis, *mimeo*, Princeton University.
- Bhargava, A., L. Franzini and W. Narendranathan, 1982, Serial correlation and the fixed effects model, *Review of Economic Studies*, 49, 533-549.
- Bresnahan, T.F., 1982, The oligopoly solution concept is identified, *Economics Letters*, 10, 87-92.
- Bresnahan, T.F., 1989, Empirical studies of industries with market power, in R. Schmalensee and R.D. Willig, *Handbook of Industrial Organisation, Volume II*, Elsevier, pp. 1011-1057.
- Breusch, T.S. and A.R. Pagan, 1979, A simple test for heteroskedasticity and random coefficient variation, *Econometrica*, 47, 1287-94.
- Bulow, J.L. and P. Klemperer, 1998, The tobacco deal, *Brookings Papers on Economic Activity*, forthcoming.
- Bulow, J.I. and P. Pfleiderer, 1983, A note on the effect of cost changes on prices, *Journal of Political Economy*, 91, 1, 182-185.
- Carlton, D.W. and J.M. Perloff, 1994, *Modern Industrial Organization*, 2nd Edition, Harper Collins, New York.
- Chaloupka, F.G. and K.E. Warner, 1998, The Economics of smoking, *The Handbook of Health Economics*, forthcoming.
- Cnossen, S., 1992, Intrigues around the tobacco excise in the European Community, *International Tax Review*, 2, 127-137.
- Coats, R.M., 1995, A note on estimating cross-border effects of state cigarette taxes, *National Tax Journal*, XLVIII, 4, 573-584.

- Corts, K.S., 1998, Conduct parameters and the measurement of market power, *Journal of Econometrics*, forthcoming.
- Cremer, H. and J-F Thisse, 1994, Commodity taxation in a differentiated oligopoly, *International Economic Review*, 35, 613-633.
- Delipalla, S. and M.J. Keen, 1992, The comparison between ad valorem and specific taxation under imperfect competition, *Journal of Public Economics*, 49, 351-367.
- European Bureau for Action on Smoking Prevention, 1995, *Tobacco and health in the European Union - An overview*, Brussels.
- Genesove, D. and W.P. Mullin, 1998, Testing static oligopoly models: conduct and cost in the sugar industry, 1890-1914, *RAND Journal of Economics*, 29, 2, 355-377.
- Geroski, P.A., 1988, In pursuit of monopoly power: Recent quantitative work in industrial economics, *Journal of Applied Econometrics*, 3, 107-123.
- Hall, R.E., 1988, The relationship between price and marginal cost in U.S. industry, *Journal of Political Economy*, 96, 921-47.
- Harris, J.E., 1987, The 1983 increase in the federal cigarette excise tax, *Tax Policy and the Economy*, 1, 87-111.
- Hyde, C.E. and J.M. Perloff, 1995, Can market power be estimated?, *Review of Industrial Organization*, 10, 465-485.
- Hsiao, C., 1986, *Analysis of Panel Data*, Cambridge University Press.
- Johnson, T.R., 1978, Additional evidence on the effects of alternative taxes on cigarette prices, *Journal of Political Economy*, 86, 2, 325-328.
- Kay, J.A. and M.J. Keen, 1983, How should commodities be taxed?, *European Economic Review*, 23, 339-358.
- Kay, J.A. and M.J. Keen, 1991, Product quality under specific and ad valorem taxation, *Public Finance Quarterly*, 19, 238-247.
- Kelejian, H., 1971, Two stage least squares and econometric systems linear in parameters but nonlinear in the endogenous variables, *Journal of the American Statistical Association*, 66, 373-374.
- Lau, L., 1982, On identifying the degree of competitiveness from industry price and output data, *Economics Letters*, 10, 93-99.
- Panzar, J.C. and J.N. Rosse, 1987, Testing for monopoly equilibrium, *Journal of Industrial Economics*, 35, 443-56.
- Poterba, J.M., 1996, Retail price reactions to changes in state and local sales taxes, *National Tax Journal*, 39, 165-176.
- Seade, J., 1985, Profitable cost increases and the shifting of taxation: Equilibrium responses of markets in oligopoly, University of Warwick Discussion Paper no. 260.
- Shapiro, M., 1987, Measuring market power in U.S. industry, National Bureau of Economic Research Working Paper No. 2212.
- Skeath, S. E. and G. E. Trandel, 1994, A Pareto comparison of ad valorem and specific taxation in noncompetitive environments, *Journal of Public Economics*, 53, 53-71.

- Sobel, R.S. and T.A. Garrett, 1997, Taxation and Product quality: New evidence from generic cigarettes, *Journal of Political Economy*, 105, 4, 880-887.
- Stern, N.H., 1987, The Effects of taxation, price control and government contracts in oligopoly and monopolistic competition, *Journal of Public Economics*, 32, 133-158.
- Sullivan, D., 1985, Testing hypothesis about firm behaviour in the cigarette industry, *Journal of Political Economy*, 93, 3, 586-598.
- Sumner, D.A., 1981, Measurement of monopoly behaviour: An application to the cigarette industry, *Journal of Political Economy*, 89, 6, 1010-1019.
- Sumner, M.T. and R. Ward, 1981, Tax changes and cigarette prices, *Journal of Political Economy*, 89, 6, 1262-1265.

Table 1: Market Shares of Five Leading Cigarette Firms, 1992/93

	Top 5 Firms					Total of Top 5	Total of Multinationals	State producer
	1	2	3	4	5			
BELGIUM	30%	28	17.8	13	6	94.8%	94.8%	0%
DENMARK	78.8	n.a.	n.a.	n.a.	n.a.	≈100	2.4	0
GERMANY	37.2	24.3	18.9	8.6	6.4	95	95	0
GREECE ¹	33.8	18.5	9.9	5.6	5.4	73.2	53	0
SPAIN	66.1	13.7	9.8	5.3	4.4	99.3	33.7	66.1
FRANCE	45.2	28.6	12.2	11.1	1.2	98.3	54.0	45.2
IRELAND ²	n.a.	n.a.	n.a.	n.a.	n.a.	≈100	≈100	0
ITALY	46.9	45	n.a.	n.a.	n.a.	≈100	55	45
LUXEMBOURG	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0
NETHERLANDS	33	25	22	15	n.a.	>95	≈95	0
PORTUGAL	92.2	6.9	0.9	0	0	100	7.8	92.2
U.K.	39.8	35.4	14.5	2.8	n.a.	>92.5	>92.5	0

Source: European Bureau for Action on Smoking Prevention (1995).

Notes

1. Shares of total sales held by 5 top domestic producers. The figure for multinationals is imports plus cigarettes produced for MNCs under license.
2. The MNCs account for almost the whole market.

Table 2: Cigarette Prices and Taxes in EU Countries

	GROSS PRICE ¹		NET PRICE ²		TOTAL TAX AS % OF GROSS PRICE		SPECIFIC TAX AS % OF TOTAL TAX	
	1982	1997	1982	1997	1982	1997	1982	1997
BELGIUM	55.21	98.41	16.28	25.26	70.51	74.33	5.04	9.38
DENMARK	132.90	143.70	17.50	25.35	86.84	82.36	54.27	49.95
GERMANY	69.26	105.70	21.52	32.33	68.93	69.40	39.65	45.47
GREECE	46.33	18.73	18.62	5.17	59.81	72.42	9.70	4.57
SPAIN ³	15.57	28.02	9.28	7.35	40.38	73.77	11.01	7.97
FRANCE	39.87	110.00	10.05	26.42	74.80	75.99	5.00	5.00
IRELAND	100.10	144.20	26.88	35.15	73.13	75.62	54.96	54.65
ITALY	50.45	51.72	13.82	13.97	72.60	72.99	1.58	5.00
LUXEMBOURG	43.45	71.95	14.80	22.55	65.95	68.66	5.15	5.03
NETHERLANDS	54.60	87.64	14.91	24.63	72.69	71.89	10.00	50.01
PORTUGAL ³	30.65	30.58	9.33	5.75	69.57	81.21	9.70	11.92
U.K.	108.90	128.80	28.10	27.40	74.20	78.73	54.12	54.41

Source: see Appendix-Data sources.

Notes:

1. Gross retail price of 1000 cigarettes in the most popular price category (MPPC) deflated by 1985 CPI, in ECUs.
2. Gross price minus total tax. Total tax = specific (unit) tax + (ad valorem) (gross price). Ad valorem is the sum of the ad valorem excise rate and VAT, both expressed as proportion of tax inclusive (gross) price.
3. For Spain and Portugal, first year is 1986, not 1982, for all variables.

Table 3: Tax Shifting Parameters From Individual Country Price Regressions

		Ad valorem	Specific	Ratio of specific to ad valorem (θ)
Belgium	(GLS)	0.7364	0.7870	1.0688
Denmark	(OLS)	0.4017*	1.0374	2.5824
France	(GLS)	0.5223	6.0432**	11.5710**
Germany	(OLS)	1.0482	0.8223	0.7845
Greece	(GLS)	1.1270	3.9724**	3.5248**
Ireland	(GLS)	0.8686	1.2746**	1.4675
Italy	(GLS)	2.7088**	3.5925**	1.3262**
Luxembourg	(OLS)	0.3275	7.0090**	21.4032**
Netherlands	(GLS)	0.5032**	0.6697*	1.3309**
Portugal	(GLS)	0.3195**	1.1390	3.5654**
Spain	(GLS)	0.4974	1.5102	3.0360
U.K.	(OLS)	1.2870	1.1081**	0.8610

Notes:

1. All parameters calculated, at respective sample means, from coefficients of price regressions. Independent variables are taxes, wages and GDP per capita. All variables in levels. Estimated by OLS, or GLS (Prais-Winsten) if Durbin-Watson did not indicate non-rejection of the null hypothesis at 1% level of significance.
2. ** and * indicates parameter is significantly different from 1 at 5% and 10% level of significance respectively based on Wald test. Highest level of significance quoted where Wald test shows inconsistency in test of mathematically equivalent linear and non-linear restrictions. Standard errors calculated by delta method.

Table 4: Estimates of Cigarette Price Equation

Dependent Variable: Price per 1000 Cigarettes

	GROUP 1 COUNTRIES		GROUP 2 COUNTRIES	
	2 WAY WG – LEVELS		1 WAY WG – LOGS	
Ad Valorem Tax	308.5128	(6.091)	5.7788	(11.189)
(Ad Valorem Tax) ²	-209.1244	(-4.050)	3.5209	(9.650)
Specific Tax	1.6250	(25.750)	0.1655	(8.609)
(Specific Tax) ²	-	-	0.0810	(2.989)
Labour Cost per Worker	0.4721	(4.700)	-0.1293	(-2.103)
GDP per capita	0.5947	(2.208)	0.1751	(4.144)
ECU Exchange Rate	-16.0185	(-9.021)	-2.2458	(-10.625)
(ECU Exchange Rate) ²	0.1381	(6.800)	0.1284	(7.671)
Adjusted R ²	0.9962		0.9912	
HOMOGENEITY [~F(k(m-1),N-(m(k+1)))]	1.7459	(0.0365)	2.5820	(0.0042)
RESET [~F(2,N-2)]	0.1422	(0.8677)	1.0190	(0.3664)
AUTOCORRELATION: - Modified Durbin-Watson - Correlation coeff. (ρ)	2.0178 -0.0059		1.8271 0.0864	
HOMOSKEDASTICITY: - Breusch-Pagan [~χ ² (k+m+T-1)]	30.25	(0.3031)	35.95	(0.0011)
SIGNIFICANCE OF: - Country Effects [~F(m-1,N-m-k)]	164.99	(0.0000)	94.83	(0.0000)
- Time Effects [~F(T-1,N-k-m-T+1)]	2.308	(0.0102)	1.539	(0.1241)
EXOGENEITY: - Country (& Time) Effects [~χ ² (k)]	138.22	(0.0000)	193.14	(0.0000)
- Taxes ~F(2,N-k)	0.0468	(0.9864)	1.0388	(0.3940)
Sargan~χ ²	6.0276	(0.9999)	30.9698	(0.2724)

Notes:

1. N - sample size; k - number of regressors; m - number of country groups; T – number of time periods.
2. Figures in parentheses next to coefficients are t-ratios (White corrected for Group 2). Figures in parentheses next to test statistics are p-values.
3. Modified Durbin-Watson is that of Bhargava *et al.* (1982).
4. Breusch-Pagan (1979) test statistic is distributed $\chi^2(k+m)$ for Group 2 where time effects are not included.
5. Sargan is test for validity of instruments for taxes (used in exogeneity test).

Table 5: Tax Shifting, Market Power and Conduct Parameters

[Calculated at respective sample means]

	GROUP 1 COUNTRIES			GROUP 2 COUNTRIES		
TAX SHIFTING	Estimate	Standard Error	(p-value)	Estimate	Standard Error	(p-value)
Ad valorem	0.7212	0.0485	(0.0000)	1.4772	0.1128	(0.0000)
Specific	0.9235	0.0359	(0.0329)	2.1654	0.2911	(0.0001)
Ratio of specific to ad valorem (θ)	1.2805	0.0721	(0.0001)	1.4659	0.2772	(0.0927) ¹
Nos. EQUIVALENT OF FIRMS	Estimate	(95% C.I.)		Estimate	(95% C.I.)	
Elasticity = -0.1	45.65	(27.69 - 63.61)		31.46	(6.44 - 56.48)	
-0.2	22.82	(13.84 - 31.80)		15.73	(3.22 - 28.24)	
-0.3	15.22	(9.23 - 21.20)		10.49	(2.15 - 18.83)	
-0.4	11.41	(6.92 - 15.90)		7.87	(1.61 - 14.12)	
-0.5	9.13	(5.54 - 12.72)		6.29	(1.29 - 11.30)	
-0.6	7.61	(4.62 - 10.60)		5.24	(1.07 - 9.41)	
-0.7	6.52	(3.96 - 9.09)		4.50	(0.92 - 8.07)	
-0.8	5.71	(3.46 - 7.95)		3.93	(0.81 - 7.06)	
-0.9	5.07	(3.08 - 7.07)		3.50	(0.72 - 6.28)	
-1.0	4.57	(2.77 - 6.36)		3.15	(0.64 - 5.65)	

Notes:

1. Standard errors calculated by delta method. p-values gives probability value from Wald test of θ being different from 1.
2. The p-value for the Wald test of the mathematically equivalent linear test of the restriction is 0.0614.