THE COMPARISON BETWEEN AD VALOREM AND SPECIFIC TAXATION UNDER IMPERFECT COMPETITION: EVIDENCE FROM THE EUROPEAN CIGARETTE INDUSTRY

Sophia Delipalla and Owen O'Donnell

February 1998

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. Empirical comparison of the price effects of the two taxes is limited. There are no previous estimates of these effects derived from data displaying reasonable variation in both types of taxes. We fill this gap by estimating the impact on prices of specific and ad valorem taxes levied on cigarettes in Europe. The results are consistent with the theory. There is evidence of under and over-shifting and the specific tax has a significantly greater effect on price than the ad valorem.

Keywords: Commodity Taxation, Oligopoly, Cigarettes.

JEL Classification: H22, L13, L66

Acknowledgements: We are grateful for comments received at seminars at Kent, Sussex and York.

Corresponding author: Sophia Delipalla, Department of Economics, Keynes College, University of Kent, Canterbury KENT CT2 7NP, UK. Tel: (++1227) 827924; Fax: (++1227) 827850; email: S.Delipalla@ukc.ac.uk

1. Introduction

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 (Delipalla and Keen, 1992; Skeath and Trandel, 1994; Myles, 1996). Empirical comparison of the price effects of the two taxes is limited. There are no previous estimates of these effects derived from data displaying reasonable variation in both types of taxes. In fact, empirical work on commodity tax incidence, in general, is sparse (rare examples are Besley and Rosen, 1994 and Poterba, 1996).

We fill this gap by estimating the impact on prices of specific and ad valorem taxes levied on cigarettes in Europe. The European cigarette industry, being highly concentrated, provides an appropriate context in which to test the recent developments in the theory of tax incidence under oligopoly. The estimates are of interest not only as tests of the predictions of theory and for drawing implications for the incidence of commodity taxes in general, but also as a source of information for the long running European debate over the harmonisation of cigarette taxes. Although all EU countries tax cigarettes heavily, there is a split between those relying more on specific taxes - roughly, the ‘north’- and those favouring ad valorem taxation - roughly, the ‘south’. These differences over the appropriate structure of taxation have impeded fiscal harmonisation in this area. 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 (Commission of the European Community, 1989). Evaluations of the effectiveness of taxation as an anti-smoking instrument concentrate on the estimation of price elasticities of demand, adopting the assumption that taxes are fully shifted onto consumers (c.f. Chaloupka and Wechsler, 1997).

Tests of the validity of this assumption are important in assessing the health policy role, and the distributional effects, of cigarette taxation.

The next section presents the theoretical framework for analysing how ad valorem and specific taxes affect prices, and summarises the existing evidence. In section 3 we describe the European cigarette industry. Section 4 describes the data and the empirical specification. Estimation is considered in section 5 and the results are reported. Section 6 concludes.

2. The relative incidence of ad valorem and specific taxes

2.1 The theory

Tax incidence is concerned with the effect of taxation upon prices and profits. Since perfectly competitive firms earn zero profits, under perfect competition there is only a price effect. Consumer prices increase by just the amount of the tax if the long run supply curve is horizontal, and by less than that if it is upward sloping. Price rising by more than the amount of the tax is not a possibility.

Under imperfect competition there are both price and profit effects. 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. Overshifting occurs when price rises by more than the amount of the tax and undershifting when it rises by less. The degree of tax shifting depends on the relative curvature of industry demand and the firm’s cost function. With constant marginal cost, concavity of industry demand leads to undershifting and sufficient convexity to overshifting (Seade, 1985; Stern, 1987).

The analysis of tax incidence becomes more interesting and complex when we consider the form of taxation. Although specific and ad valorem taxes have identical effects under the assumptions of perfect competition and exogenous quality, their equivalence breaks down when either assumption is relaxed (Keen, 1997). With respect to the introduction of imperfect competition, Suits and Musgrave (1955) show, for the monopoly case, ad valorem taxation is consistent with a lower after-tax price, for a given tax revenue. More recent studies have concentrated on the systematic comparison between specific and ad valorem taxation in varying circumstances of homogeneous product oligopoly (Delipalla and Keen, 1992; Skeath and Trandel, 1994; Myles, 1996). Consider the conjectural variations model, as in Delipalla and Keen (op. cit.), which encompasses market structures ranging from competitive outcomes to monopoly.

It is assumed the industry consists of n identical firms. The after-tax profit earned by a typical firm (i) is

$$\pi_i = \{(1-tv)p(X)-ts\}x_i - c(x_i), \tag{2.1}$$

where p is the consumer price, X is the industry output, x_i is the firm's output and ts and tv are the specific and ad valorem tax rates respectively. There are increasing returns to scale and $c(x_i)$ is the firm's total cost of producing the given level of output. The strategic interaction between firms is captured by λ: each firm conjectures that, when it changes its output x_i, other firms' responses will be such that $\frac{dX}{dx_i} = \lambda \in [0,n]$. With $\lambda = 0$, conjectures are "competitive"; $\lambda = 1$ corresponds to Cournot conjectures and $\lambda = n$ to tacit collusion.

The first-order condition for profit maximisation is given by

$$p = \left(\frac{1}{1-tv}\right)\left(\frac{1}{1-\frac{\gamma}{\varepsilon}}\right)\left(c_x + ts\right) = \left(\frac{1}{1-tv}\right)\theta\left(c_x + ts\right), \qquad (2.2)$$

where $\gamma = \frac{\lambda}{n}$, $\varepsilon = -\frac{dX}{dp}\frac{p}{X}$, $\theta = \left(\frac{1}{1-\frac{\gamma}{\varepsilon}}\right) \geq 1$, and c_x is marginal cost. Here θ measures the degree to which a firm is not a price taker. The marginal effect of each tax on price is given by

$$\frac{dp}{dts} = \left(\frac{1}{1-tv}\right)\frac{1}{1+\gamma(1+A-E)} > 0 \qquad (2.3)$$

and[1]

$$\frac{dp}{pdtv} = \frac{1}{\theta}\left(\frac{1}{1-tv}\right)\frac{1}{1+\gamma(1+A-E)} = \frac{1}{\theta}\frac{dp}{dts}, \qquad (2.4)$$

where $A = -c_{xx} / \lambda(1-tv)p_X$ and $E = -p_{XX}X / p_X$ denotes the elasticity of the slope of the inverse demand function (single and double subscripts indicate first and second derivatives respectively).

Though not noted before, from (2.4), we see that 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 we have the well known result that the two taxes have equivalent effects on price in a competitive environment. However, with imperfect competition (i.e. $\theta > 1$), the price effect of the specific tax exceeds that of the ad valorem tax by a proportion given by the value of the mark-up.

---

[1] To enable comparison with the effect of the specific tax, we present the impact on price of a unit change in tax revenue arising from a change in the ad valorem tax rate (at initial price),

There is full shifting of a tax onto the consumer if the producer price, $p' = (1 - tv)p - ts$, is invariant to the level of the tax. The degree of tax shifting is given by

$$\frac{dp'}{dts} = \frac{dp}{dts}(1 - tv) - 1 \tag{2.5}$$

and

$$\frac{dp'}{pdtv} = \frac{dp}{pdtv}(1 - tv) - 1 \tag{2.6}$$

Expressions (2.5) and (2.6) are less than, equal to and greater than zero with undershifting, full shifting and overshifting respectively. Comparing (2.5) and (2.6) with (2.3) and (2.4), it is clear that under perfect competition ($\theta = 1$, $\gamma = 0$), there must be full shifting of both taxes, but otherwise ($\theta > 1$, $\gamma > 0$) there can be undershifting, full shifting or overshifting, depending upon the value of parameters related to the market structure, cost structure and demand elasticity of the industry.[2] Also, overshifting of the specific tax is necessary but not sufficient for overshifting of the ad valorem tax.

Prior to the oligopoly model considered above, consideration of the relative price effects of ad valorem and specific taxes focussed on their impact on quality in competitive markets (Barzel, 1976; Bohanon and Van Cott, 1984, 1991; Kay and Keen, 1983, 1987a, 1987b, 1991).

With vertical product differentiation, since commodities are composed of a set of characteristics, a tax can induce substitution within the commodity away from the taxed

---

i.e. *pdtv*.

[2] 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 ($A = 0$) and constant elasticity of demand ($E = 1 + 1/\varepsilon$), there will be full shifting of the ad valorem tax

characteristic into others. 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 $\frac{1}{1-tv} > 1$. 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.[3]

Formalising these ideas, Kay and Keen (1991) show, in a model of competitive behaviour, that the effect of tax structure on quality is determined by the price elasticity of consumers' marginal willingness to pay for quality, say η. Overshifting of the specific tax and undershifting of the ad valorem is predicted when η takes a value between 0 and 1. If η = 1, there is overshifting of the specific and full shifting of the ad valorem tax. When η = 0, the specific tax is fully shifted and the ad valorem undershifted. It is argued that values outside the [0,1] range, although theoretically possible, are unlikely.

The ranking of the relative price effects in the quality model (specific effect always greater than the ad valorem) is consistent with that generated by the oligopoly model of Delipalla and Keen (1992). An estimate of the ratio of the two price effects is therefore insufficient to

(and overshifting of the specific tax).

[3] 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.

distinguish empirically between the two models. However, while the oligopoly model allows under or over shifting of both taxes simultaneously, the competitive endogenous quality model is consistent with this only for, arguably, implausible values of η.

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 relative incidence of the two taxes carry over to a model with horizontally differentiated products in Bertrand-Nash oligopoly.[4]

2.2 The evidence

Cigarettes, for one reason or another, have been a popular commodity for estimating the price effects of specific and ad valorem taxes. Barzel (1976) did this by exploiting state variation in these 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. Barzel (ibid.) 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.

[4] 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.

The 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 (op. cit.) 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.[5] A number of studies are motivated to estimate tax-price relationships not because of an interest in tax incidence but as an indirect means of estimating market power (Sumner, 1981; Bulow and Pfleiderer 1983; Sullivan, 1985; Ashenfelter and Sullivan, 1987).

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

[5] Coats (1995) estimates cross-border effects of state cigarette taxes looking at 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).

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.

A major limitation of previous attempts to estimate the relative incidence of specific and ad valorem taxes is a lack of variation in the data, particularly with respect to the ad valorem rate. We avoid this limitation by using data from the EU, where all member states levy both a VAT and an excise duty on tobacco, alcohol and petrol. Moreover, although the excise duty on alcohol and petrol is purely specific, the one on cigarettes has both a specific and an ad valorem element.

3. The European tobacco industry and the EU

The European tobacco industry is characterised by a high degree of concentration, making it an appropriate environment for testing the theory of tax incidence under imperfect competition. There are state monopolies in France, Italy, Spain and Portugal, which have a significant, but diminishing (except Spain), share of the domestic market (Eurostat, 1997). In most of the remaining countries, the market is dominated by a group of American and British multinationals. The exception is Denmark, where one company (Skandinavisk Tobak) enjoys an almost monopoly position (Eurostat, ibid.).

The EU is divided into two opposing camps, roughly a north-south divide, with respect to the structure of taxation preferred. In general, the northern European countries prefer specific taxation and the southern countries ad valorem.[6] The theory discussed in section 2, if valid, is

[6] The ‘northern’ camp consists of Denmark, Germany, Ireland, the Netherlands and UK. The ‘southern’ group is Belgium, France, Greece, Italy, Luxembourg, Portugal and Spain. For more details see European Bureau for Action on Smoking Prevention (1992).

useful in understanding such preferences. According to the theory, specific taxation leads to higher prices, for a given tax revenue, and so may be preferred in northern Europe where smoking prevention movements are more firmly established.[7] On the other hand, in southern countries, such as Greece, 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.

These differences led to major difficulties in trying to reach agreement on the harmonisation of taxes on cigarettes in the EU. The first 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 the ad valorem 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 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 5-55% 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%

---

[7] 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 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.

4. Empirical specification and data

Our aim is to compare the effects of specific and ad valorem taxes on cigarette prices. We achieve this by regressing price data from twelve European countries over sixteen years on corresponding tax data and controls for other determinants of prices. According to equation (2.2), price is a mark-up on marginal cost and the specific tax, with the mark-up determined by the ad valorem tax rate, market structure, demand and cost conditions. No data are available on marginal costs, market structure or demand conditions. Replacing these by observable (Z) and unobservable (u) determinants gives the following relationship to be estimated

$$p_{it} = f_{it}\left(ts_{it}, tv_{it}, Z_{it}, u_{it}\right) \tag{4.1}$$

where i and t are country and time indicators respectively.

Approximating this function by assuming linearity and homogeneity across countries and time leads to the following empirical specification[8]

---

of smoking, such as filters.

[8] The Davidson and McKinnon (1981) test was not helpful in selecting between log-linear and levels specifications. Reset tests favoured the latter. The linear specification was tested against various generalisations achieved by allowing quadratics and interaction terms. The restricted model could not be rejected. Our estimation methods allow for country and time effects within

$$p_{it} = \alpha_1 ts_{it} + \alpha_2 tv_{it} + Z_{it}\beta + u_{it} \tag{4.2}$$

From examination of (4.2) along with (2.5) and (2.6), it is clear that although this specification imposes homogeneity across countries and time in the response of consumer prices to the specific and ad valorem taxes, this is not true with respect to the response of producer prices and, therefore, the degree of tax shifting. The latter effects vary with the rate of the ad valorem tax (and the price in the case of the effect of the ad valorem).[9]

Define $\hat{\theta} = \frac{\hat{\alpha}_1}{\hat{\alpha}_2}\bar{p}$, where ^ indicates an estimate and $\bar{p}$ is a particular price. Testing whether $\hat{\theta}$ is significantly different from 1 is a test of whether the price effects of the specific and ad valorem tax are equivalent.[10]

Equation (4.2) is estimated from data on cigarette prices and taxes for the twelve members of the European Union prior to the 1995 expansion. For ten of these countries, the data cover the period 1982-97; for Spain and Portugal, the period covered is 1986-97. The data are for prices and taxes in operation at January 1 of each year.[11]

---

the error term.

[9] Besley and Rosen (1994) have to work with producer prices as the dependent variable and so force the tax shifting parameter to be homogenous across observations. We test and subsequently (partially) relax the assumption of homogeneity of the parameters α_1, α_2 and β across countries.

[10] Wald tests are used. Given Wald tests of restrictions which are non-linear in parameters are not invariant to (mathematically equivalent) reformulations, we also tested for non-equivalence of the tax effects through a restriction on the difference between the coefficients. However, no inconsistencies were discovered and we present the test results for the formulation given in the text.

[11] 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.

The price data are for 1000 cigarettes in the most popular price category (MPPC). Obviously the MPPC will vary across countries and, potentially, also across time. Variation across countries can be dealt with by specifying country effects within the error term. Variation across time is more difficult to accommodate since this time effect would not be common across countries. An estimation problem would arise if switches in the MPPC were 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 brand - 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.[12,13] As with all of the control (*Z*) variables, the data are for the year

[12] 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

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.

According to theory, market structure is an important determinant of price. A lack of data makes it difficult to control explicitly for market structure. However, this is not a major limitation since, as described above, there is relatively little variation in the structure of the cigarette industry across countries and time. Any variation in market structure which does exist in the sample is dealt with through appropriate specification of the error term i.e. allowing country and time effects.

5. Estimation and results

OLS estimates of equation (4.2) are given in the first column of Table 1. All the coefficients take the anticipated sign and are significant. But these estimates must be treated with caution given the potential for heterogeneity bias. The next two columns give estimates from the two

---

labour costs per worker between 1995 and 1996.

[13] 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.

way error components model estimated by the within groups (WG) and feasible GLS (FGLS) methods respectively.[14] *A priori*, the fixed effects specification, which motivates the WG estimator, might be expected to be preferable since, as argued in section 3, unobservable country specific factors which influence cigarette prices may also be correlated with cigarette taxes. Hausman (1978) tests do indeed reject exogeneity of the country effects at the 10% level and of both country and time effects jointly at the 5% level.

The modified Durbin Watson statistic (Bhargava et al, 1982), calculated from the WG residuals, indicates a problem of autocorrelation. Fixed and random effects estimates obtained from Cochrane-Orcutt transformed data, denoted by WG-AR(1) and FGLS-AR(1) respectively, are given in columns 4 and 5 of Table 1. The time effects lose significance and have been suppressed. Purging the first-order autoregression results in a substantial increase in the magnitude of the coefficients on the tax variables.

While the within groups method allows for correlation between country fixed effects and the regressors,[15] there remains the potential for misspecification through the tax variables being causally dependent on prices. Such dependence might arise from the EU rules on the level and structure of cigarette taxation described in section 3. 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

---

[14] Given the nature of the data set, the time-series cross-section (TSCS) FGLS method, *a la* Kmenta (1986, pp. 616-625), is an alternative to the error component model employed. Beck and Katz (1995) report Monte Carlo evidence showing the TSCS method gives standard errors which are seriously downward biased and there is little improvement in efficiency over OLS unless the number of time periods exceeds the numbers of individual units by a factor much greater than three. Baltagi (1986) also provides some support for the error component model over the TSCS method.

as a proportion of total taxes will require a shift in the balance of taxation following certain price movements. However, a Hausman test, based on comparison between WG and two-stage within groups (WG-2SLS) estimates in which the tax variables are instrumented, indicates that the null of exogeneity cannot be rejected (see bottom of column 4, Table 1).[16,17]

Given one might expect delays in the adjustment of prices to changes in tax rates, costs and demand conditions, the static models considered so far may be misspecified. A lagged dependent variable can be included among the regressors to capture a partial adjustment mechanism (Greene, 1993, pp. 798-9). However, with such a dynamic specification, the within groups and random effects estimators are biased and consistency depends on the number of time periods (T) being large (Baltagi, 1996, p.126). Nickell (1981) shows the bias of the within groups estimator is of $O(1/T)$. Since $T = 16$ (12 in some cases) in this application, the bias is relatively small. Further, there is evidence, based on Monte Carlos and forecasting performance, that the inconsistent fixed and random effects estimators for dynamic panel data models perform well relative to consistent (for $N \to \infty$) IV estimators (Kiviet, 1995; Harris and Matyas, 1996; Baltagi and Griffin, 1997). These findings are likely to be particularly true for applications, such as this, with relatively small N and large T. We therefore restrict our estimation of the dynamic model to the WG and FGLS methods.

---

[15] The null of zero correlation is not rejected for the estimates purged of autocorrelation.

[16] 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. See Appendix for descriptions and sources. A Sargan test could not reject the null of these being a valid set of instruments at the 5% level.

[17] Since the WG-2SLS estimator is simply 2SLS with a set of dummies for the individual effects (Baltagi, 1996, pp. 109-113), autocorrelation can be dealt with in the standard way for 2SLS (Greene, 1993, pp.748-9).

WG and FGLS estimates of the dynamic model are presented in columns 6 and 7 of Table 1. Time effects are again insignificant and have been suppressed. Exogeneity of the country effects is rejected, which suggests the WG estimates are superior. As would be expected, inclusion of the lagged dependent variable greatly reduces the problem of autocorrelation. However, from the 5% critical values presented in Bhargava et al (1982), the modified Durbin-Watson statistic appears to be less than the lower bound, indicating some serial correlation remains in the WG estimates. Purging this serial correlation will not necessarily improve efficiency since yet another observation will be lost from each group, given the Cochrane-Orcutt transformation must be used with the WG estimator. We found that performing the transformation resulted in a substantial deterioration in the Reset statistic and therefore prefer the estimates obtained from the untransformed data. Again, the exogeneity of the taxes could not be rejected.

The lagged dependent variable is significant (1%) and, from the WG estimate, suggests an average lag length of 1.43 years. Consequently, there are large differences between the short and long run estimates of the tax effects. The long run responses are quite close, particularly for the ad valorem tax, to those obtained from the static model with correction for first order autoregression.

The estimates discussed so far were generated under the assumption of parameter homogeneity across all countries. Chow tests reject this restriction.[18] The appropriate response requires consideration of a trade-off between bias and efficiency. Baltagi and Griffin (1997) compare the forecast performance of pooled homogeneous parameter models with

[18] The F-test statistics for the restriction imposed on the WG estimates of the static and

heterogeneous alternatives in the context of a dynamic model. For forecasts any longer than one year, the fixed and random effects estimators outperform their heterogeneous parameter counterparts. These results were obtained for a time series roughly double the length of the present one. Consequently, in this application, it is unlikely that any gains from reduced bias through allowing full parameter heterogeneity could compensate for the loss of efficiency.

While efficiency concerns rule out allowing full parameter heterogeneity across countries, there may be gains from allowing partial heterogeneity. Given the large differences in the level and structure of taxation between the northern and southern countries, one might expect them to experience different tax-price relationships. Tests consistently rejected imposition of parameter homogeneity across the northern and southern groups.[19] Judging that efficiency losses from splitting the sample in two might not outweigh gains from relaxing the misspecification of parameter homogeneity, we present estimates from the two sub-samples in Table 2.

Hausman tests show a preference for the WG estimator over FGLS for the 'north' and the opposite for the 'south'. Autocorrelation was always present in the static models and we present results for estimates purged of first order autoregression. Tests do not reject the null of both taxes being exogenous.

Comparing the estimates of the static models, the tax coefficients for the southern countries are consistently greater than those for the northern group, particularly with respect to the

---

dynamic models respectively are 25.787 (p=0.0000) and 23.976 (p=0.0000).

[19] Wald tests, robust to inequality between error variances, were conducted for all estimation methods (Ohtani and Kobayashi, 1986). In addition, F-tests were carried out on the within

specific tax. The appropriateness of the dynamic specification differs across the two groups. The lagged price term is small and insignificant for the north but large and significant for the south. Apparently, cigarette prices are more flexible in northern than southern Europe. Given the presence of state monopolies in some of the southern countries, this result is consistent with theories predicting negative correlation between market concentration and price flexibility (c.f. Means, 1972). For the ad valorem tax, while the short run price effect is much smaller in the south, once the difference in lag length is allowed for, the long run effects are similar across the two camps. The specific tax has a much greater short and long run effect in the south than in the north.

For the south, the modified Durbin-Watson statistic indicates the presence of autocorrelation in the dynamic estimates. Purging first order autoregression using Cochrane-Orcutt does not result in the deterioration of the Reset test statistic which occurred when this procedure was applied to the dynamic model estimated on the full sample. We therefore present the FGLS serial correlation corrected results for the south. Purging first order autoregression leads to a fall in the average lag length which results in a decrease in the long run effect of the specific tax. Otherwise the estimates are quite robust to this transformation.

In Table 3 we present estimates of the tax shifting parameters and test statistics for the null of equivalence between the price effects of specific and ad valorem taxation. Estimates are presented for the whole sample and the two sub-samples, using the specifications indicated by the diagnostics to be most appropriate in each case. The estimates are calculated at the respective sample means. First, consider the estimates obtained under the restriction of

---

groups estimates.

parameter homogeneity across the whole sample. In the static model, the tax shifting parameters are less than, but close to, one. The specific parameter is significantly less than one at the 5% level, while the undershifting of the ad valorem tax is only significant at the 10% level. The estimates should be interpreted as indicating that a unit increase in the specific tax results in an increase in the price paid by consumers of 0.9, while a unit increase in tax generated by a change in the ad valorem rate raises the consumer price by 0.84. The greater impact of the specific tax on the consumer price is consistent with the theory considered in section 2. However, the difference is not statistically significant.[20]

Turning to the dynamic specification, we find significant undershifting of both taxes in the short run. In the long run, the shifting parameters are less than and greater than one for the ad valorem and specific taxes respectively, but neither is significantly different from one, suggesting that full shifting cannot be rejected in either case. The impact of the specific tax on price is again greater than that of the ad valorem and the difference is significant at the 10% level.

Splitting the sample between the northern and southern countries leads to very different estimates of tax incidence. For the northern group, we consider estimates of the shifting parameters derived from the static model only, since the dynamic specification did not appear appropriate in this case. There is evidence of significant undershifting of the ad valorem tax. A unit increase in tax levied through an increase in the ad valorem rate, generates a 0.65 rise in the consumer price. In the north, the incidence of the ad valorem taxes levied on cigarettes is split between consumers and producers, with the former incurring the greater burden. On

[20] The same pattern of results is obtained for shifting parameters calculated from the WG-AR1

the other hand, the estimate of the shifting parameter for the specific tax is greater than one, but not significantly so. The price effects of the taxes are significantly different (5%). There is undershifting of the ad valorem tax and full shifting of the specific tax.[21] This finding is consistent with producers lobbying governments to maintain reliance on specific taxes in these countries.

The effects of the two taxes are quite different for the countries relying predominantly on ad valorem taxation - the south. Using the estimates from the static specification, both shifting parameters are greater than one, but only that for the specific tax is significantly so. The estimate suggests overshifting of the specific tax to the extent that a unit increase in the tax results in a 1.66 increase in the consumer price. Turning to results generated from the dynamic specification, there is significant undershifting of the ad valorem tax in the short run but full shifting in the long run. For the specific tax, one cannot reject full shifting in the short run, but in the long run there appears to be a great deal of overshifting - a unit increase in the tax raises the price paid by consumers by 3. There is a substantial and significant difference between the taxes in terms of their impact on price.

6. Conclusions

Under the restriction that the response of consumer prices to specific and ad valorem taxation is the same throughout the EU, there is little evidence from our results against full shifting of both taxes. However, once this restriction is relaxed, as the data suggest it should be, the estimates show that among countries which rely more heavily on specific taxation (north), there is undershifting of ad valorem and full shifting of specific taxes. In the countries where there is greater reliance on ad valorem taxation (south), the estimates show full shifting of the

---

estimates.

ad valorem and overshifting of the specific. In both cases, the specific tax has a significantly greater effect on price than the ad valorem.

These results support the theoretical predictions from Delipalla and Keen (1992) that under/overshifting is possible and that the specific tax always has a bigger impact on price. According to their imperfect competition model, whether a tax is under- or overshifted depends on factors related to the gradients of the demand and cost functions; the extent of shifting depends upon the number of firms and their conjectures. Differences between the northern and southern countries with respect to these factors may explain why the tax effects are not the same. Cost and demand characteristics differ - the south produces its own tobacco and attitudes toward smoking make demand less elastic. The degree of concentration (number of firms) also differs - state monopolies existed in some southern countries during our sample period.

As discussed in section 2, different price effects of specific and ad valorem taxes might be attributed to quality adjustment. For our estimates to be consistent with the quality model (Kay and Keen, 1991), the marginal willingness to pay for quality must be independent of price in the north and unit elastic in the south. Therefore, the quality model is supported by the results only in so far as this set of parameter values is plausible.

We have little reason to suspect our results are reflecting a cross-border shopping effect; there is only one case of undershifting - ad valorem taxation in the north.

---

[21] The results are very similar using the estimates from the dynamic specification.

The implications of these results go beyond the testing of theory. 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 will not always have empirical validity.

Under the assumption of full shifting, cigarette taxation has been found to be regressive. Given the finding on overshifting of the specific tax 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 that there is evidence for undershifting of the ad valorem tax. In both cases, the empirical findings suggest a more careful analysis of the tax incidence. A similar warning applies to analysts of cigarette taxation as an instrument of health policy.

Finally, the empirical findings are very interesting with reference to the EU tax harmonisation debate. Northern countries lobby for specific taxation, which happens to be the tax which bears the greatest relative burden on the consumer; southern countries lobby for ad valorem taxation, which bears a lower relative burden on the consumer. This might suggest different distributional objectives by the “northern” and “southern” governments. It helps to remind ourselves of the strong presence of the multinationals’ and health lobbies in the north and the existence of state monopolies for manufacturing and distribution in the south. If what the northern governments want is high prices, to satisfy the health lobby, and high profits, to please the multinationals, specific taxation is the preferred one. But, as long as southern governments have different objectives, the harmonisation debate is not going to be resolved.

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.

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., 1986, Pooling under misspecification: Some Monte Carlo evidence on the Kmenta and the error components techniques, *Econometric Theory* 2, 429-40.

Baltagi, B.H., 1996, *Econometric Analysis of Panel Data*, Wiley, Chichester.

Baltagi, B.H. and J.M. Griffin, 1997, Pooled estimators vs. their heterogeneous counterparts in the context of dynamic demand for gasoline, *Journal of Econometrics* 77, 303-327.

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.

Beck, N. and J.N. Katz, 1995, What to do (and what not to do) with time-series cross-section data, *American Political Science Review* 89, 3, 634-647.

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.

Bohanon, C.E. and T.N. van Cott, 1984, Specific taxes, product quality and rate-revenue analysis, *Public Finance Quarterly* 12, 500-511.

Bohanon, C.E. and T.N. van Cott, 1991, Product quality and taxation: A reconciliation, *Public Finance Quarterly* 19, 233-237.

Breusch, T.S. and A.R. Pagan, 1979, A simple test for heteroskedasticity and random coefficient variation, *Econometrica* 47, 1287-94.

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.

Chaloupka, F.G. and H. Wechsler, 1997, Price, tobacco control policies and smoking among young adults, *Journal of Health Economics*, 16, 3, 359-373.

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.

Commission of the European Communities, 1989, Amended proposals for a council directive on the approximation of taxes on cigarettes, Brussels.

Cremer, H. and J-F Thisse, 1994, Commodity taxation in a differentiated oligopoly, *International Economic Review* 35, 613-633.

Davidson, J. and R. McKinnon, 1981, Several tests for model specification in the presence of alternative hypothesis, *Econometrica* 49, 781-793.

Delipalla, S. and M.J. Keen, 1992, The comparison between ad valorem and specific taxation under imperfect competition, *Journal of Public Economics* 49, 351-167.

European Bureau for Action on Smoking Prevention, 1992, *Taxes on tobacco products - A health issue*, Brussels.

Eurostat, 1997, *Panorama of the EU Industry*, vol.1, EC DXIII, Luxembourg.

Greene, W.H., 1993, *Econometric Analysis*, Prentice Hall, New Jersey.

Harris, J.E., 1987, The 1983 increase in the federal cigarette excise tax, *Tax Policy and the Economy* 1, 87-111.

Harris, M.N. and L. Matyas, 1996, A comparative analysis of different estimators for dynamic panel data models, *mimeo*, Department of Economics, Monash University.

Hausman, J.A., 1978, Specification tests in econometrics, *Econometrica* 46, 1251-71.

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, 1987a, Commodity taxation for maximum revenue, *Public Finance Quarterly* 15, 371-385.

Kay, J.A. and M.J. Keen, 1987b, Alcohol and tobacco excises: Criteria for harmonisation, in S Cnossen, eds., *Tax coordination in the European Community* (Kluwer Law and Taxation, Deventer).

Kay, J.A. and M.J. Keen, 1991, Product quality under specific and ad valorem taxation, *Public Finance Quarterly* 19, 238-247.

Keen, M.J., 1998, Specific versus ad valorem taxation, *Fiscal Studies*, forthcoming.

Kiviet, J.F., 1995, On bias, inconsistency and the efficiency of some estimators in dynamic panel data models, *Journal of Econometrics* 68, 53-78.

Kmenta, J., 1986, *Elements of Econometrics*, 2nd Edition, New York, Macmillan.

Means, G.C., 1972, The administered-price theories reconfirmed, *American Economic Review* 62, 292-306.

Myles, G., 1996, Imperfect competition and the optimal combination of ad valorem and specific taxation, *International Tax and Public Finance* 3, 29-44.

Nickell, S., 1981, Bias in dynamic models with fixed effects, *Econometrica* 49, 1417-1426.

Ohtani, O. and M. Kobayashi, 1986, A bounds test for equality between sets of coefficients in two linear regression models under heteroscedasticity, *Econometric Theory* 2, 220-230.

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.

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.

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.

Suits, D.A. and R.A. Musgrave, 1955, Ad valorem and unit taxes compared, *Quarterly Journal of Economics* 67, 598-604.

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: ESTIMATES OF CIGARETTE PRICE EQUATION - ALL COUNTRIES

Dependent Variable: Price per 1000 Cigarettes

	ESTIMATION METHOD						
	STATIC					DYNAMIC	
VARIABLE	OLS	WG	FGLS	WG-AR(1)	FGLS-AR(1)	WG-LDV	FGLS-LDV
Ad Valorem Tax	90.913	46.737	51.526	135.67	131.86	56.753	49.196
	(6.256)	(3.760)	(5.221)	(9.074)	(9.704)	(5.599)	(6.305)
- Long Run						137.66	142.59
						(5.359)	(7.840)
Specific Tax	1.9256	1.0495	1.3126	1.9043	1.9284	0.9983	0.8063
	(34.329)	(7.496)	(11.037)	(18.352)	(19.367)	(7.311)	(9.207)
- Long Run						2.4214	2.3369
						(3.820)	(5.529)
Labour Cost per Worker	1.1596	0.7235	0.6044	0.6807	0.7103	0.0656	0.2228
	(5.828)	(3.063)	(3.161)	(4.562)	(4.043)	(0.404)	(1.714)
GDP per capita	1.1568	1.9822	1.8107	0.9652	1.1230	0.7898	0.5677
	(3.987)	(6.003)	(5.582)	(2.348)	(2.725)	(3.551)	(2.330)
ECU Exchange Rate	0.0039	-0.0051	-0.0061	-0.0103	-0.0087	-0.0042	-0.0010
	(3.472)	(-1.075)	(-1.392)	(-3.934)	(-1.676)	(-2.150)	(-0485)
Constant	-52.201	-9.4995	-13.850		-64.292		-27.283
	(-5.336)	(-0.832)	(-1.709)		(-5.666)		(-5.062)
Lagged Price						0.5877	0.6550
						(7.695)	(14.987)
Adjusted R^2	0.9251	0.9817	0.8599	0.9215	0.8160	0.9895	0.9775
RESET [~F(3,N-3)]	21.872 [0.0000]	1.5250 [0.2106]		2.1794 [0.0929]		3.5840 [0.0154]	
AUTOCORRELATION:							
Durbin-Watson	0.3894	0.4333				1.4176	
Correlation coefficient (ρ)	0.8053	0.6069	0.5707	-0.0269	-0.0018	0.1611	0.0540
HOMOSKEDASTICITY:							
Breusch-Pagan [$\sim\chi^2$(k+m+T)]	79.41 [0.0000]	130.47 [0.0000]		79.73 [0.0000]		65.15 [0.0000]	
Bartlett [$\sim\chi^2$(m-1)]	87.56 [0.0000]	52.85 [0.0000]		35.58 [0.0004]		42.80 [0.0000]	
SIGNIFICANCE OF:							
Country Effects [~F(m-1,N-k-m+1)]		38.867 [0.0000]		13.614 [0.0000]		8.523 [0.0000]	
Time Effects [~F(T-1,N-k-m-T+1)]		2.487 [0.0027]		1.459 [0.1351]		1.396 [0.1634]	
EXOGENEITY:							
Country Effects [$\sim\chi^2$(k)]			9.36 [0.0954]		5.80 [0.3257]		26.46 [0.0002]
Country & Time Effects [$\sim\chi^2$(k)]			19.36 [0.0016]				
Ad Valorem & Specific Taxes [~F(2,N-k)]				1.5732 [0.2108]		1.4403 [0.2402]	

TABLE 2: ESTIMATES OF CIGARETTE PRICE EQUATION - 'NORTHERN' AND 'SOUTHERN' COUNTRIES

Dependent Variable: Price per 1000 Cigarettes

	NORTH		SOUTH				
	STATIC	DYNAMIC	STATIC		DYNAMIC		
VARIABLE	WG-AR(1)	WG	WG-AR(1)	FGLS-AR(1)	WG	FGLS	FGLS-AR(1)
Ad Valorem Tax	113.08	109.90	157.24	157.57	29.816	29.514	36.803
	(12.824)	(14.406)	(5.615)	(6.075)	(4.797)	(3.471)	(2.984)
- Long Run		112.72			117.63	138.61	139.38
		(23.076)			(3.331)	(3.387)	(3.704)
Specific Tax	1.684	1.678	4.745	4.800	2.591	2.164	2.324
	(24.764)	(25.015)	(5.489)	(6.221)	(4.315)	(3.683)	(3.593)
- Long Run		1.721			10.222	10.163	8.800
		(14.725)			(3.060)	(3.106)	(3.35)
Labour Cost per Worker	0.2412	0.2005	0.6625	0.6645	-0.2900	-0.1895	-0.0809
	(2.220)	(2.138)	(2.409)	(2.231)	(-1.202)	(-0.750)	(-0.282)
GDP per capita	0.6080	0.5387	0.6378	0.7791	0.6288	0.5546	0.5303
	(2.630)	(2.608)	(1.348)	(1.337)	(2.324)	(1.890)	(1.535)
ECU Exchange Rate	-15.389	-15.504	-0.0104	-0.0088	-0.0048	-0.0025	-0.0023
	(-9.338)	(-11.758)	(-3.207)	(-1.613)	(-2.160)	(-1.020)	(-0.831)
Constant				-88.424		-15.062	-16.664
				(-4.244)		(-2.347)	(-2.185)
Lagged Price		0.0250			0.7465	0.7871	0.7359
		(0.596)			(9.894)	(12.611)	(10.398)
Adjusted R^2	0.9910	0.9940	0.8792	0.6216	0.9839	0.9639	0.9593
RESET [~F(3,N-3)]	0.4282 [0.7335]	1.9327 [0.1335]	4.0008 [0.0106]		2.9793 [0.0367]		
AUTOCORRELATION:							
Durbin-Watson		1.7212			1.5311		
Correlation coefficient (ρ)	-0.0915	0.0524	-0.0330	-0.0388	0.1506	0.1159	-0.0793
HOMOSKEDASTICITY:							
Breusch-Pagan [$\sim\chi^2$(k+m)]	21.78 [0.0096]	25.78 [0.0041]	39.02 [0.0001]		45.55 [0.0000]		
Bartlett [$\sim\chi^2$(m-1)]	8.91 [0.0616]	9.61 [0.0476]	18.62 [0.0095]		20.32 [0.0049]		
SIGNIFICANCE OF:							
Country Effects [~F(m-1,N-m-k+1)]	32.851 [0.0000]	31.201 [0.0000]	14.418 [0.0000]		5.891 [0.0000]		
EXOGENEITY:							
Country Effects [$\sim\chi^2$(k)]	53.81 [0.0000]	70.79 [0.0000]		3.28 [0.6570]		5.02 [0.5412]	6.52 [0.3677]
Ad Valorem & Specific Taxes [~F(2,N-k)]	1.4304 [0.2468]	1.5009 [0.2308]	1.9311 [0.1519]		0.8385 [0.4362]		

Notes to Table 1 and Table 2:

1. N - sample size; k - number of regressors; m - number of country groups; T - number of time periods.
2. Figures in parentheses below coefficients are White corrected t-ratios. Those for FGLS not White corrected.
3. Figures in brackets beside diagnostics are p-values.
4. For the WG estimates, Durbin-Watson is that of Bhargava et al (1982).
5. Breusch-Pagan (1979) and Bartlett (Kmenta, 1986, 297-98) are tests for homoskedasticity against the alternatives of observation and group specific variances respectively.

TABLE 3

ESTIMATES OF TAX SHIFTING PARAMETERS AND TESTS OF EQUIVALENCE ($\theta = 1$)

[Calculated at (sub-) sample means]

	Ad Valorem Tax	Specific Tax	Ratio of Specific to Ad Valorem Price Effect (θ)
ALL COUNTRIES			
STATIC: FGLS-AR(1)	0.8383 (0.0612)	0.8980 (0.0279)	1.0713 (0.1910)
DYNAMIC: WG			
- Short Run	0.3608 (0.0000)	0.4649 (0.0000)	
- Long Run	0.8751 (0.4445)	1.1276 (0.6656)	1.2885 (0.0957)
NORTH			
STATIC: WG-AR(1)	0.6543 (0.0000)	1.0357 (0.3928)	1.5829 (0.0000)
SOUTH			
STATIC: FGLS-AR(1)	1.1651 (0.3897)	1.6618 (0.0132)	1.4263 (0.0551)
DYNAMIC: FGLS-AR(1)			
- Short Run	0.2678 (0.0000)	0.7969 (0.3599)	
- Long Run	1.0141 (0.9590)	3.018 (0.0251)	2.9761 (0.0109)

Note:
Figures in parentheses are p-values for Wald tests of whether parameters are significantly different from 1.