

# Price Elasticity of Demand for Tobacco in Ireland

W. K. O'RIORDAN

---

THIS short study is an attempt to estimate the price elasticity of demand for tobacco in Ireland. Tobacco was chosen, partly because of its importance as a source of tax revenue, and partly because of certain simplifying factors in its demand structure. These latter are the lack of close substitutes, the absence of stocks held by consumers, and the fact that it is used by all classes in the community.

Statistical methods may be applied to either cross-section or time series data. As the manufacturers were not willing to make available sufficient cross-section data, time series were chosen, although with some reluctance. In using time series to find a relationship between price and quantity one must take into account all other variables likely to affect the quantity demanded. The more important of these appear to be: (a) real income in the community; (b) the proportion of filter-tip cigarettes being bought, since this type of cigarette reduces the amount of tobacco used; (c) the publicity given to medical inquiries relating smoking to lung cancer—hereafter called “cancer scares”; (d) the volume of advertising in the industry, and (e) a time trend, since this gave important results in Sachrin’s investigation in the USA.<sup>1</sup>

In problems of this type one must consider whether a single or multi-equation model should be used. Multiple-equation models are necessary when price and quantity are simultaneously determined. In the present case, a single-equation model seems appropriate because price is determined primarily by the level of indirect tax levied on tobacco, and by the price of tobacco leaf. Both of these being exogenously determined, price can be regarded as an independent variable. The model can thus be expressed as a single equation, with quantity as the dependent, and price, income and so forth, as the independent variables. Multiple regression can then be applied to give unbiased, consistent and efficient estimates.

1. Sachrin, *The Demand for Cigarettes*. Agricultural Economics Research, (U.S. Department of Agriculture), Vol. 14, No. 3.

In this context the concept of price needs some comment. During a period of rising prices it is scarcely realistic to regard actual price as the significant variable. It is reasonable to believe that if income and all prices were multiplied by the same factor, the expenditure pattern would remain the same. If this is accepted, and if it is accepted further that there are no close substitutes for tobacco whose prices might have a special relevance, the relative price of tobacco seems to be the correct price-variable to use. "Relative price" is here defined as the ratio between tobacco price and the general price level.

There is insufficient a priori information for us to know whether the relationship is linear, or whether some other form is appropriate. A certain amount of experiment is indicated here. Another difficulty arises concerning the interpretation of the results of regression analysis. Geary has argued that it is dangerous to rely too much on individual constants derived from multiple regression. An attempt has been made to overcome this objection by showing that the results hold when the model is reduced to a simple relation involving only two variables.

Data are needed for the following:—(a) quantity of tobacco; (b) relative price of tobacco; (c) real national income; (d) the proportion of filter-tip cigarettes being bought; (e) the cancer scares; (f) the volume of advertising in the tobacco industry.

(a) Yearly data on the quantity of tobacco sold in Ireland are published by the Tobacco Research Council.<sup>2</sup> I believe this provides a better measure than the data published by the Central Statistics Office. Although actual quantities are given in the Council's pamphlet, only expenditure figures are available from the CSO, and the deflation of these by a price index is rather unsatisfactory.

(b) Relative price of tobacco. This variable is intended to measure the ratio between the price of tobacco and the general price level. A national average price for cigarettes and tobacco was supplied by the Central Statistics Office. This was divided by the consumer price index and the result expressed in index form.

(c) Real national income. The most appropriate measure here is of course disposable income, because it indicates the amount available to consumers. However, I found that in practice the use of GNP gave identical results; and since this is defined with less ambiguity I preferred to use it. Constant price income is used.

(d) Percentage filter-tip. This series was derived from statistics supplied by the two major tobacco companies. It represents the percentage of total volume sales accounted for by ordinary (i.e. not king size) filter-tip cigarettes.

(e) Cancer scares were recognised in two separate years. In summer, 1962, the Report of the Royal College of Physicians appeared; and in early 1965, that of the American Surgeon-General. A dummy variable was inserted in each of these years. An experiment with a dummy variable in all years since 1962 did not give significant results.

(f) It proved impossible to obtain data for advertising expenditure due to a very understandable reluctance on the part of the companies involved to release

2. *Research Paper No. 6*, Tobacco Research Council, London. The references are mainly to the table concerning Ireland, pp. 32-33.

such information. Nevertheless, I would judge that, having regard to the results below, my conclusions may not be seriously impaired by the omission of this variable.

All the series are on a yearly basis for the period 1953-1967, the choice of period and interval both being dictated by practical considerations. The year 1967 is the latest for which figures are available. It is possible to obtain data for years earlier than 1953; but 15 observations seemed sufficient for my purposes, and to go further back in time might include a period when habits were different from those of today. There is no way of avoiding the yearly interval between observations because in most cases information is available in no other form.

The first result is obtained from a regression involving all the variables listed above. The symbols are defined as follows:

$T$  = Quantity of tobacco purchased in millions of pounds (weight) per annum

$P$  = Relative price index for tobacco.

$Y$  = Gross National Product at constant prices.

$F$  = Percentage of total sales of cigarettes accounted for by ordinary filter tips.

$CD$  = A dummy variable to take account of the cancer scares in the years 1962 and 1965.

This regression gives

I

$$T = 17.03 - .1202P + .01257Y - .002772F - .02556CD$$

$$\begin{array}{cccc} (.000225) & (.00000880) & (.000200) & (.000404) \end{array}$$

$$R = .934$$

The figures in brackets are estimated variances of the constants.

There is no special reason why the equation must be linear, so it seems worth trying one that is linear in the logarithms. Such a relation is appropriate where a given proportionate change in price causes a constant proportionate change in quantity. This form has the practical advantage that the elasticity can be read off directly. The result is:—

II

$$\text{Log } T = 3.0309 - .8652 \text{ Log } P + .5442 \text{ Log } Y + .0041 \text{ Log } F - .0076 \text{ Log } CD$$

$$\begin{array}{cccc} (.0111) & (.0211) & (.000143) & (.000360) \end{array}$$

$$R = .954$$

There is a small increase in the size of the correlation coefficient; but there is no clear evidence that the logarithmic form is the more appropriate.

Before commenting on this I want to show the effect of including time as a variable. It is reasonable to believe that there could be a slow, and more or less regular, change in smoking habits over a period. This could be confused with the change in price, which also has a fairly strong time trend. The inclusion of time as a variable may help to isolate the real price effect in a more accurate way. Incidentally, this process gives the same result as if one expressed each variable in terms of its deviations from a linear trend and calculated a regression between these deviations.<sup>3</sup>

This yields:

(a) *linear*

III

$$T = 12.20 - .08974P + .01651Y - .01171F - .02411CD - .1056Z$$

$$\begin{array}{cccccc} & (.00126) & (.0000262) & (.000291) & (.000411) & (.0124) \end{array}$$

$$R = .940$$

(b) *logarithmic*

IV

$$\text{Log } T = 2.9286 - .7481 \text{ Log } P + .4808 \text{ Log } Y + .0122 \text{ Log } F - .0079 \text{ Log } CD$$

$$\begin{array}{cccc} & (.3295) & (.3559) & (.0019) & (.00094) \\ & & & & - .0201 \text{ Log } Z \\ & & & & (.0051) \end{array}$$

$$R = .965$$

The symbol  $Z$  represents time measured in years, origin 1953.

The principal interest centres on the value of the coefficient associated with  $P$  in these regressions. At least it has the expected sign, as have all the coefficients, with the exception of  $F$  in the logarithmic regressions. The surprising thing is its large size (in an absolute sense, ignoring the negative sign). The implications are more obvious when we think about it in terms of elasticity. This can be seen directly in the logarithmic forms, giving the values  $-.87$  and  $-.75$  in regressions II and IV respectively. In linear forms the elasticity varies from point to point, and the value can only be calculated at a given point. Using the mean values of  $T$  and  $P$ , one obtains estimates of  $-.92$  and  $-.69$  for I and III.

The existence of such a high elasticity is worth discussion; but first I wish to present some further empirical results.

3. See, for example, Tintner, *Econometrics* (11:1.1), Wiley, New York.

It appears that the degree of correlation between the explanatory variables is low, so that the coefficient relating quantity to price is not affected significantly by dropping the variables for filter-tip and cancer scares. One could not, of course, assume a priori that this would be so and it was necessary to try the effect of including these variables. I am not saying that these variables do not affect demand, but rather that the data come in such a form that they do not make any important difference to the result in which I am interested. I present below the results of four regressions where quantity is regarded as a function of the two most important variables, namely price and income. This is done in the original data and in logarithms, both with and without a time trend.

V

$$T = 17.52 - .1192P + .01161Y$$

$$(\cdot000208) (\cdot00000271)$$

$$R = .923$$

VI

$$T = 14.41 - .09586P + .01370Y - .08758Z$$

$$(\cdot000764) (\cdot00000715) (\cdot00780)$$

$$R = .929$$

VII

$$\text{Log } T = 2.8053 - .8431 \text{ Log } P + .5630 \text{ Log } Y$$

$$(\cdot00937) (\cdot00588)$$

$$R = .929$$

VIII

$$\text{Log } T = 2.1059 - .6915 \text{ Log } P + .5697 \text{ Log } Y - .0208 \text{ Log } Z$$

$$(\cdot0193) (\cdot00538) (\cdot000201)$$

$$R = .941$$

The price elasticities of demand derived from these results are (V) - .91, (VI) - .73, (VII) - .84, (VIII) - .69.

I have tried one final approach to the problem. It can be validly said that it is dangerous to rely too much on a single constant in a multiple regression as a predictor of what will happen to the dependent variable, if the relevant independent variable is changed while all the others are held constant. This point becomes more important the higher the degree of correlation between the independent variables. The problem does not seem to be very great in the present case, but nevertheless it is worth making an attempt to overcome the objection.

It appears that we may assume that the two important determinants of tobacco consumption are relative price and income. It will be more convenient to think of the logarithmic relationship

$$\text{Log } T = a + b \text{ Log } P + c \text{ Log } Y$$

which is equivalent to

$$T = aP^bY^c$$

If we can obtain an estimate of  $c$  from independent data this constant ( $c^*$ ) can be inserted in the equation giving

$$T = aP^bY^{c^*} \quad \text{or} \quad T = aP^bY^{c^*}$$

This is now a relationship between two variables  $T$  and  $P$ , and the objection with which we have been concerned is removed.

It is in fact possible to obtain estimates of  $c^*$  which is the income elasticity of demand for tobacco. This has been done by Leser in a study of household expenditure based on the Household Budget Enquiry of 1951-2.<sup>4</sup> The elasticity which he calculated was .830. However, as his data are rather old, I felt it preferable to repeat the investigation using his methods and the data from the more recent budget survey of 1965-6. This gave a figure of .930 for income elasticity.

A series for  $\frac{T}{Y^{.930}}$  was calculated and this series was regressed on  $P$  in the logarithmic form  $\text{Log } \frac{T}{Y^{.930}} = a + b \text{ Log } P$ .

with the result  $\text{Log } \frac{T}{Y^{.930}} = 2.9350 - 1.3176 \text{ Log } P$ .

which implies an elasticity of  $-1.3176$ . If time is included in the regression (which of course re-introduces all the difficulties associated with the original objection) the price elasticity is reduced to  $-.854$ .

This result, introduced merely as corroborative evidence, need not be taken too seriously, because one must have some doubts about the reliability of the estimate of income elasticity based on cross-section data. This "independent estimate" is derived from the change in spending habits between groups at a given moment. This need not necessarily be an accurate indicator of the changes which would take place when the whole group received an increase in income over a period.

It seems that three empirical facts emerge:

(a) The inclusion of variables for the percentage of filter-tips and the cancer scares does not affect the price elasticity significantly.

(b) There is a negative time trend which may be due to a similar trend in the relative price level or to some other regularly changing factor. (My opinion is that the increasing tendency on the part of young people to avoid smoking is at work here).

(c) The lowest possible estimate of the relative price elasticity of demand is  $-.70$ . A more likely value would seem to be in the range  $-.80$  to  $-.90$ .

4. C. E. V. Leser, *Demand Relationships for Ireland*, Economic Research Institute, Paper No. 4, Dublin.

The most important conclusion is that, since the elasticity is so high, a rise in the tax rate will cause a substantial decline in the quantity of tobacco purchased, provided, of course, that income remains unchanged. However, it must be remembered that the price used is relative price, and that it is assumed in the analysis that changes in price which simply maintain the existing relation between tobacco and the general price level have a neutral effect. Thus for the rest of the paper, statements about price will be taken to refer to relative price. The terms income and revenue will refer to real and not money values.

To avoid ambiguity, define "price" as being the manufacturer's price, and "total price" as being "price" plus indirect tax. I think it reasonable to suppose that tax on tobacco is about 70 per cent. of total price. Assume that tax is increased by 14 per cent. This will raise total price by 10 per cent. With an elasticity of  $-0.8$ , quantity will fall by 8 per cent. Since there is no change in price, revenue in the industry will decrease by 8 per cent also, which must have a very considerable effect. With quantity now at 92 per cent of its previous level, and the tax rate at 114 per cent, tax receipts will rise by slightly under 5 per cent. It would seem that the tobacco processors can validly claim that they are being victimised: that tax increases bringing a relatively small amount of revenue cause serious shocks to the industry.

It is true that the volume of tobacco purchased has oscillated around 13 million pounds per annum during the entire period. If my results are acceptable, it would seem that the positive effect of rising income has tended to cancel the negative effect of rising relative price. The theory that we have reached saturation level is, in my opinion, not tenable. An examination of the historical data available<sup>5</sup> shows no case of a country reaching saturation level anywhere near our consumption of 6.6 lbs. per head.

Thus, Irish taxation policy is preventing the tobacco industry from reaping the benefits in expansion which would naturally follow a rising national income. Moreover, the greater part of the increases in tax revenue would have accrued whether the tax rates were increased or not, because most of the extra income is due to the income effect. It may be perfectly reasonable to restrict the consumption of tobacco on medical grounds; but if this is the policy which is being carried out it ought to be stated openly. To claim that an increase in tobacco price has little effect on demand is grossly inaccurate. A period of stagnant income would demonstrate the very small returns from increases in the rate of tax on tobacco.

<sup>5</sup> *Research Paper No. 6*, Tobacco Research Council, London.