

Models of Irish Tobacco Consumption

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Abstract: This paper estimates several econometric models of tobacco consumption, employing Irish annual time series data. The approaches examined include the recently developed rational addiction model and a two-component model that separates participation as a smoker from consumption by smokers. No evidence was found to favour the rational addiction model. The proportion of smokers seems unaffected by price or income, but shows a substantial downward trend related to health concerns. In contrast, consumption by smokers shows no such trend, but is affected by price with a relatively low price elasticity. The implications are discussed.

I INTRODUCTION

Analysis of Irish tobacco consumption, in terms of the factors influencing its evolution over time, is of interest for several reasons. One is that medical and statistical evidence of the damaging effects of smoking on health have accumulated over the years and the reduction of smoking is now an important objective of Government health policy (Department of Health, 1994). Another reason is that in the years since the publication of the substantial studies by O'Riordan (1969) and Walsh (1980), not only have extra data accrued, but some new approaches to modelling tobacco expenditures have appeared in the international literature. These seek to incorporate the addictive element of smoking behaviour into the econometric model. Quite strong claims have been made for some of these approaches and they deserve trial with Irish data.

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Section II of this paper outlines the various models that have been employed in the literature and that are used later in the paper. Section III reviews the literature, both on previous Irish research and on the relevant findings from international research. The current Irish data available for analysis are described in Section IV and analysed in Section V. Finally, Section VI reviews and discusses the conclusions.

II MODELS OF TOBACCO CONSUMPTION

The simplest econometric models of tobacco consumption, which until relatively recently, were also the most frequently employed, were those conventionally used for non-addictive commodities. That is, they related annual quantities consumed (usually on a per-adult basis) to deflated price and income. Proxy variables to allow for such factors as publicity concerning the health dangers attached to smoking and the introduction of restrictions on the promotion of tobacco products were often added to equations, usually in the forms of time trends and "dummy" variables. The addictive component in smoking did not appear explicitly in the demand equation.

Adding the lagged value of consumption as an additional variable is an easy way to make current consumption dependent on the level already attained and this provides one way of representing addiction. A price decrease now increases consumption in the current period and also has a feed forward effect, because the new consumption level influences future consumption. The model can be criticised as an unrealistically simple representation of the addictive process, but it can serve as a starting point to discuss other models.

The rational addiction model proposed by Becker and Murphy (1988) and applied to smoking by Becker, Grossman and Murphy (1994) allows the smokers to be rational in the sense that they appreciate that an increase in their current consumption level will addict them to a higher level of consumption in the future. So if they anticipate future price rises, they may be reluctant to increase their current consumption even if real current price has fallen somewhat. The theoretical development by Becker and Murphy assumes the individual makes decisions to increase or reduce tobacco consumption based on maximisation of a time-additive utility function, assuming that the smoker has knowledge, not only of the increasing tolerance effect, but of other consequences of smoking and of future prices. The outcome of the utility maximisation is an equation for current period consumption q_t of the form

$$q_t = a_0 + a_p p_t + a_1 q_{t-1} + a_f q_{t+1} \quad (1)$$

which differs from the conventional lagged dependent variable model if a_f is different from zero. In practice, other variables need to be included in the model and estimation is complicated by the endogeneity of q_{t+1} .

Another approach to modelling addiction, by Young (1983), introduced asymmetric price effects. The idea is that, if smoking is truly addictive, the effect of a real current price decrease can only be reversed in a future period by a larger price increase. A conventional model, even with a lagged dependent variable, is obviously symmetrically reversible in the long run. This assumption can be overcome by including the variables

$$M_t = \Sigma^*(p_t - p_{t-1}) \text{ and } N_t = \Sigma^*(p_{t-1} - p_t), \tag{2}$$

where the summations are over the years prior to year t and the asterisks indicate that differences are included in M only if $p_t > p_{t-1}$ and in N only if $p_t < p_{t-1}$ and are otherwise omitted. Thus M_t will change only when there is a real price increase and will hold a value until there is another real price increase.

A third approach, adopted, for example, by Lewit, Coate and Grossman (1981), is to consider a two step model, where the first equation relates the probability of abstinence from smoking to price, income and other factors. The second equation relates the consumption per smoker to the same set of factors. The equations to be estimated are of the form

$$\log \frac{z_t}{1-z_t} = r_o + r_p p_t + r_y y_t \tag{3}$$

and

$$q_t^* = b_o + b_p p_t + b_y y_t, \tag{4}$$

where z_t is the proportion of smokers in the population in year t and a logistic type model is envisaged, since relating a proportion to a linear function of variables is not good practice. The price and income elasticities from Equation (3) are $r_p(1-z)/p$ and $r_y(1-z)/y$. In the quantity equation the asterisk indicates that quantity is on a per smoker rather than a per adult basis. As before, of course, the equations could also contain other explanatory variables and lagged dependent variables. The formulation allows the possibility that some factors may operate in one equation and not the other.

The choice of functional form is rarely clear-cut in applied economics and tobacco consumption is no exception. While the rational addiction approach does lead to the linear functional form (1), the familiar double-log and budget

share forms also occur in the literature. In this study linear and double-log forms will be employed and also the logistic form

$$\log \frac{w}{1-w} = c_0 + c_p \log p + c_y \log y, \quad (5)$$

where w is the "budget share" of tobacco. This is a modification of the well-known share model of Leser (1964), which has certain advantages described by Conniffe (1993). The price and income elasticities for this model are

$$c_p(1-w)-1 \text{ and } c_y(1-w)+1 \text{ respectively.}$$

III REVIEW OF LITERATURE

While the relevant Irish literature is sparse enough, there is a very extensive international literature relating tobacco consumption to various factors. This review will briefly summarise a representative section of the literature, before giving a more detailed account of applications of the relatively recently developed models described in the previous section.

Table 1 summarises Irish time-series based studies in terms of estimates of price and income elasticities of tobacco consumption. There has been some use of Irish household budget survey data to estimate income elasticities but since these surveys are conducted only at seven year intervals, with price effectively constant within surveys, price elasticities are unobtainable. With the exception of O'Riordan (1969), who obtained data on consumption by weight of tobacco from the industry's Tobacco Research Council, the authors used the CSO's *National Income and Expenditure Accounts* as data sources. The magnitudes of elasticities, especially those for income, seem to decrease over time, a point to which Walsh (1980) drew special attention.

Table 2 gives elasticity estimates for some UK and US studies. With the exception of the value found for male smokers by Atkinson and Skegg (1973)

Table 1: *Summary of Irish Time Series Based Elasticity Estimates of Tobacco Consumption*

<i>Author</i>	<i>Time Span</i>	<i>Functional Form</i>	<i>Price Elasticity</i>	<i>Income Elasticity</i>
O'Riordan (1969)	1953-67	Double-log	-.86	.54
McCarthy (1977)	1953-74	Linear	-.15	.15
Walsh (1980)	1953-60	Double-log	-.79	.33
	1961-76	Double-log	-.38	-.09
Madden (1993)	1958-88	Variants of Share form	-.33 to -.68	-.20 to .35

(these authors drew on Tobacco Research Council data to separate consumption by gender, which is impossible with the Official Statistics data employed by others) and that found by McGuinness and Cowling (1975), the price elasticities are reasonably similar, but estimates of income elasticities are more variable. Some of the variation in findings may be due to differing treatments of other factors. Sumner (1971) added a time trend to allow for health education effects, while Atkinson and Skegg (1973) employed dummy variables to represent transient effects of important publications on smoking and health. Hamilton (1972) included dummy variables for health reports, anti-smoking legislation and a measure of tobacco companies' advertising. He found substantial effects of the former factors and a negligible effect of the latter. On the other hand, McGuinness and Cowling (1975) found a large advertising effect, but felt that health education could do no more than weaken the promotional effect of advertising. Radfar (1985) also reported finding an advertising effect. The evidence in favour of including lagged consumption in equations was not clearcut. McGuinness and Cowling (1975) did not find lagged consumption statistically significant. Hamilton (1972) did find a significant, but small effect, and Radfar (1985) reported a more substantial effect.

Table 2: Summary of Some UK and US Elasticity Estimates of Tobacco Consumption

Author(s)	Country	Time-Span	Functional Form	Lagged		
				Con- sumption ^a	Price Elasticity	Income Elasticity
Stone (1945)	UK	1920-39	Double-log	NO	-.51	.07
Lyon and Simon (1968)	US	1951-64	Undefined ^b	NO	-.51	—
Houthakker and Taylor (1970)	US	1929-70	Linear	YES	-.53	.86
Sumner (1971)	UK	1955-67	Double-log	NO	-.48	.20
Hamilton (1972)	US	1926-70	Double-log ^c	YES	-.51	.73
Atkinson and Skegg (1973)	UK	1951-70	Double-log	NO	Male .00	.34
				Female	-.48	1.21
McGuinness and Cowling (1975)	UK	1957-78 ^d	Double-log	YES	-1.04	.33
Fujii (1980)	US	1929-73	Double-log ^c	YES	-.47	.22
Witt and Pass (1981)	UK	1955-75	Double-log	NO	-.32	.13
Radfar (1985)	UK	1965-80 ^d	Double-log	YES	-.37	.20

^aWhere a lagged consumption is included, the elasticities given are long run.

^bLyon and Simon based estimates on changes before and after price changes in US states.

^cThese authors also estimated linear forms.

^dThese authors used quarterly data.

Becker, Grossman and Murphy (1994) used US data on per capita cigarette consumption in the various states for the years from 1955 to 1985 to estimate the model (1) using two-stage least squares with p_{t-1} and p_{t+1} included among the instrumental variables. They estimated a long-run price elasticity of $-.75$, which contained an element of rational foresight. The authors maintained they had demonstrated that a price rise in any year had not only decreased consumption in that and subsequent years, but was responsible for decreases in previous years. Rational foresight, if real, would imply that statements by a Minister for Finance about increases in future taxation of tobacco would be a potent policy instrument. Becker, *et al.*, also estimated (1) by ordinary least squares, although appreciating that endogeneity of q_{t+1} would imply inconsistent estimates. Nevertheless, they felt the large coefficient obtained for this variable supported the argument for rational addiction. They used dummy variables assigned to all years to try to eliminate the effect of factors such as developing health concerns about smoking. Because they had time series for 50 states, with prices varying due to differing tax levels, they could still estimate effects in spite of a large number of dummy variables.

Chaloupka (1991) has also applied the Becker-Murphy model, but to data on individuals drawn from a US National Health and Nutrition survey. He also found smokers to display rational foresight, obtained substantial price effects and estimated that a future price change that would reduce future consumption by 10 per cent would reduce current consumption by up to 5 per cent. Labeaga (1993) has applied the model to Spanish household panel data and he too claims to have verified the reality of rational addictive behaviour by smokers.

Turning to the other models introduced in Section II, Young (1983) took the US data previously examined by Fujii (1980) and separated the price effect into a symmetric, or standard, component and an asymmetric component, so that a greater price increase may be required to offset the effect of an earlier price decrease. The approach employs the quantities M_t and N_t defined in Equation (2). He obtained a larger overall price effect than Fujii had, some of that being the "irreversible" component.

The studies by Lewit, Coate and Grossman (1981) and Lewit and Coate (1982) used different equations to separate participation or non-participation in smoking from the amount consumed by smokers. Their data were obtained from detailed surveys on individuals and they were not only able to separate participation and quantity, but to do so for various age groups. They found low price elasticities for quantity smoked for all age groups with the magnitudes greatest for teenagers ($-.25$ as compared with $-.15$ for the over 35s). They found participation price elasticities high for young people, although low for older people. However, their findings in this regard have not been

reproduced by other researchers. A recent study by Wasserman, Manning, Newhouse and Winkler (1993), using much the same methodology and similar, but extra and more recent data, found that price elasticities for teenagers were not significantly different than for older adults and that the participation price elasticities were small in magnitude. They did agree with the earlier studies in finding very low income elasticities.

The Wasserman *et al.*, study drew data from nine years of a US wide national health survey, so that there was price variation across time as well as across states. Lewit and Coate (1982) was based on only one survey year, but geographical variation in prices still permitted estimates of price elasticities. There have been some detailed surveys of Irish smokers; for example, a 1980 survey on smokers in general described by O'Connor and Daly (1985) and a 1984 survey on smoking by Dublin school children reported by Grube and Morgan (1986). Again, however, absence of price variation between individuals prevents estimation of price elasticities.

IV DATA

Tobacco is consumed in the forms of manufactured cigarettes, "roll-your-own" tobacco, cigars and pipe tobacco. Data on these components are available from the Reports of the Revenue Commissioners, but combining over components is probably best performed in terms of expenditures rather than weights of tobacco. The combined expenditures at current and constant price are given in the CSO's *National Income and Expenditure Accounts*. Expenditure at constant price was taken as a quantity measure and converted to a per adult basis by dividing by the population aged 15 and over. A real price measure was obtained by dividing current by constant expenditure and deflating by the Consumer Price Index. The income measure was taken as total personal expenditure at constant prices on a per adult basis. Data from 1960 to 1990 were employed and the trends in consumption per adult and real price are shown in Figures 1a and 1b.

Available data on proportions of smokers in the population are much more limited. Commencing in 1972, the Department of Health commissioned surveys from market research companies, initially biennially, but later annually. The surveys were conducted in rounds from July of a year through to the following June. The surveys related to cigarette smokers (including "roll-your-own") only and just to "regular" (at least one a day) consumers, so may have underestimated numbers a little, but this should not affect the changes over time. But also there were changes in details of the survey between 1984 and 1985, coinciding with a change in the firms conducting the surveys, including a change of definition of adult (16 to 15). The percentages

of smokers in the adult population are shown in Figure 1c and show a clear trend decrease, in spite of a discontinuity in 1984. Consumption per smoker can be obtained by dividing consumption per adult by the proportion of smokers, although interpolation is required to achieve common time points. This is shown in Figure 1d. There is no trend decline, but comparison with Figure 1b, from the early 1970s on, suggests an inverse, if imprecise, relationship with real price.

Figure 1a: *Tobacco Consumption per Adult, 1960-1990*

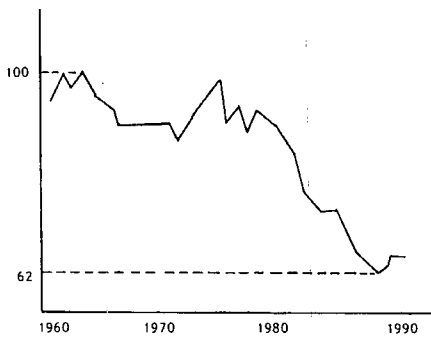


Figure 1c: *Smokers as Percentages of the Adult Population, 1972-1990*

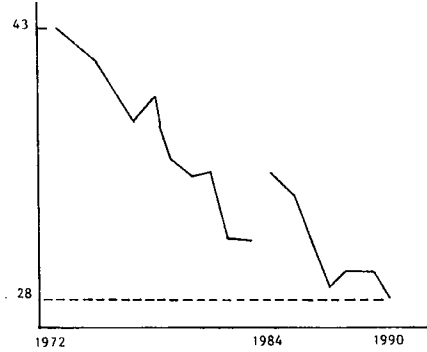


Figure 1b: *Real Price of Tobacco, 1960-1990*

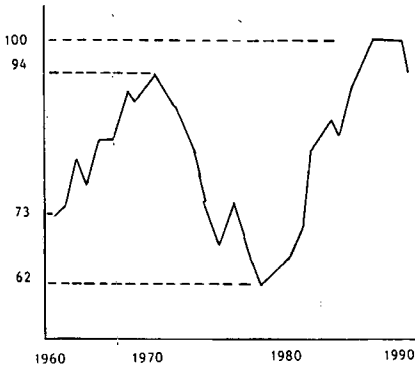
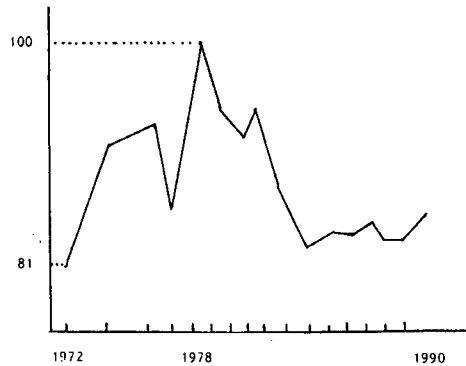


Figure 1d: *Consumption per Smoker, 1972-1990*



V ESTIMATION AND ANALYSIS

The series of models described in Section II could all be augmented by the addition of a time trend and/or dummy variables to represent the publication of health reports, the inception of anti-smoking campaigns, and enactment of legislation affecting the promotion of tobacco sales or regulating the locations where smoking is permissible. Had there been only a few such shocks to the

tobacco market, it might have been feasible to isolate and measure the impact of each of them through corresponding dummy variables. But a lot of measures have been introduced in Ireland and at least some of these could be envisaged to have phased effects necessitating more than one dummy variable. The literature review of Section III did not imply that any particular measures could definitely be taken as unimportant. Furthermore, most Irish smokers see British television and newspapers and the level of interest in British sporting fixtures (often sponsored by tobacco companies) is high. So it would be logical to also allow for major developments in the UK. The difficulty is that a case could be made for attaching dummy variables to most of the years of observations. A more parsimonious procedure is to postulate an induced downwards trend and test the adequacy of this approximation by adding a few dummy variables to capture possible further effects of the shocks. Perhaps, unsurprisingly, these failed to prove statistically significant except in one case, which will be mentioned later. As will be seen, however, the time trend was substantial.

Starting with a simple model allowing for addiction by the inclusion of a lagged dependent variable, Table 3 gives the resulting coefficients and short- and long-run elasticities. For the variable elasticity models the long-run elasticities are given at both the mean and for the end of the period.

Table 3: *Model Coefficients and Elasticities for Lagged Dependent Variable Models*

Model	Coefficients					Elasticities					R ²
	p	y	t	q _{t-1}	PSRM	PLRM	PLRE	YSRM	YLRM	YLRE	
Linear	-82.50 (-5.4)	0.02 (3.0)	-3.61 (-6.7)	0.16 (1.4)	-0.32	-0.38	-0.57	0.29	0.34	0.58	0.97
Double-log	-0.29 (-5.4)	0.30 (3.5)	-0.02 (-6.8)	0.25 (2.6)	-0.29	-0.39	-0.39	0.30	0.40	0.40	0.98
Logistic	0.63 (7.3)	-0.70 (-7.0)	-0.02 (-5.4)	0.03 (0.3)	-0.40	-0.39	-0.37	0.34	0.32	0.31	0.99

Notes: T-values are in parentheses below coefficients and the subscripts to elasticities have the meanings: SRM = short-run at the mean, LRM = long-run at the mean, LRE = long-run at end of period.

The lagged dependent variable was statistically significant only in the constant elasticity model and not particularly large even then, so that there is little overall difference between short- and long-run elasticities. The elasticity estimates from all three models are quite similar at the mean, which is not surprising, but they are not dramatically different at the end of the period either. The degree to which the models can be considered to account well with the data needs more examination and Table 4 gives a range of criteria and

tests of fit. For the double-log and logistic models there are indications that the deterministic component may contain specification error. In the former model, the test for stability over time is close to significant at 5 per cent (the critical value is 2.7) and one of the RESET tests is significant. For the logistic model the tests are even more unfavourable. The linear model does pass muster in the sense of no specification test proving significant at a 5 per cent level, although a graphical inspection of residual plots suggests even this is less than perfect. As will be discussed later, perhaps no *single* equation model should be expected to provide an ideal fit.

Table 4: *Goodness of Fit and Specification Tests*

Criteria	LINEAR		DOUBLE-LOG		LOGISTIC	
		PROB		PROB		PROB
F test for Stability over Time ¹	2.4	(5,20) >.05	2.6	(5,20) \approx .05	4.4	(5,20) <.01
RESET (2) F test for Model Adequacy	3.3	(1,24) >.05	5.5	(1,24) <.05	4.4	(1,24) <.05
RESET (3) F test for Model Adequacy	1.6	(2,23) >.05	3.1	(2,23) >.05	4.2	(2,23) <.05
Score test (χ^2) for Serial Correlation	9.5	(9) >.05	12.4	(9) >.05	10.4	(9) >.05
Runs Test on Residuals	-1.1	>.05	0.1	>.05	0.93	>.05

¹This is the largest of the F tests obtainable by dividing the data into pairs of groups and testing for change in coefficients between pairs.

The rational addiction model of Equation (1) with income and a time trend added was estimated by two-stage least squares, using p_{t-1} and p_{t+1} as extra instrumental variables. Following Becker, *et al.* (1994) as closely as possible, the equation was also estimated by ordinary least squares in spite of the econometric objection of lack of estimator consistency. The equations are estimated for 29 observations, because of the unusability of first and final observations with lagging and leading.

The key coefficients for the rational addiction models are those of q_{t-1} and q_{t+1} in the equations. Significance of the former would be taken by Becker, *et al.*, as showing "addiction", while significance of the latter would be taken as showing "rational" or "non-myopic" behaviour. For the 2SLS equation, Becker, *et al.*, presented t-values of 8.9 and 2.4 for lagged and future consumption, which were, of course, statistically significant. The corresponding T-values in Table 5 are nowhere near significance. For the OLS equation, Becker, *et al.*, obtained even larger T-values, but again the Table 5 values do

Table 5: Testing the Becker-Murphy Rational Addiction Models

Variable	2SLS Equations		OLS Equation	
	Coefficient	T-Value	Coefficient	T-Value
q_{t-1}	-0.09	(-4)	.16	(1.3)
p_t	-110.40	(-4.1)	-85.83	(-4.9)
q_{t+1}	-0.06	(-3)	-0.06	(-4)
y	0.02	(2.3)	0.02	(2.6)
t	-4.70	(-3.8)	-3.93	(-4.5)

not suggest significance. The linear equation of Becker, *et al.*, arose from their utility maximisation and it is unclear what form of equation would have resulted from other forms of utility functions. It probably remains within the spirit of the rational addiction framework to add lagged and future consumption to the basic log linear and logistic equations. However, the results were no different.

Turning to the asymmetric price response model, the quantities M_t and N_t defined in Equation (2), were calculated and considered as additional variables. Although reported as working well for US data by Young (1983), the model led to extreme multicollinearity problems with Irish data. The problem is that M_t and N_t are monotonic increasing and become highly correlated with the time trend. For example, the sign of N_t "ought" to be positive because the effect of past real price decreases should have stimulated cigarette smoking. Similarly, the coefficient on M_t should be negative (and smaller than that on N_t if this concept of addiction is valid). But the coefficients came out with incorrect signs. Deleting the time trend from the model does produce the correct hypothesised signs, but the negative coefficient of M_t instead of being smaller than that of N_t is vastly larger, because this variable is now catching the health awareness and legislation effects previously proxied by the time trend. The results are too unstable to be worth presenting.

In the two equation model, the first relates the proportion, or percentage, of smokers among adults to the various factors and the second relates quantity consumed to the same variables. If this is a plausible formulation, it also implies that analysis of average adult consumption alone must have defects and may explain the instability detected in Table 4. For the proportion (or percentage), one candidate equation is of the form (3) and another is the obvious variant, obtained by replacing p and y with their logs. This has price and income elasticities of $r_p(1-z)$ and $r_y(1-z)$. As regards variables to proxy health awareness and other effects, a dummy variable to change the intercept corresponding to post-1984 values proved necessary even with the inclusion of a time trend. The need may be related to the change in survey

Table 6: *Analysis of the Proportion of Smokers Among Adults*

Model	Coefficients				Elasticities				R ²	D-W ^a
	p	y	t	D	p _m	p _e	y _m	y _e		
Linear in Price and Income	-0.192 (-1.2)	0.000 (.1)	-0.048 (-7.4)	0.194 (4.1)	-0.14	-0.13	0.00	0.00	0.96	2.40
Log-linear in Price and Income	-0.154 (-1.1)	0.005 (.2)	-0.048 (-7.1)	0.189 (4.0)	-0.10	-0.11	0.00	0.00	0.96	2.40

Notes: T-values are in parentheses. The subscripts m and e refer to elasticities calculated at the mean and at the end of the period.

^aThe D-W test is not the best test for serial correlation when the initial observations are less correlated (biennial surveys) than later ones. However, if the serial correlation is 0 the D-W value would still be expected to be close to 2 and the statistic would have the same null distribution.

procedure mentioned in Section IV as much as to a deviation from linearity in the effects of the proxied factors. Table 6 shows the results of the estimation.¹

Both models give similar results. The time trend and the dummy variable are both highly statistically significant. The income coefficient is almost zero and, of course, not statistically significant. The price coefficient is also nowhere near statistical significance, but at least the estimate is a negative value and perhaps a much larger sample might have established significance. But it seems that the proportion of smokers in the population, or the probability that any individual is a smoker, is effectively unrelated to price and income. However, the proportion has been changing greatly over time, indicating that the proxied factors of health awareness and State intervention in the tobacco market has been having substantial effects. It may be worth mentioning that a lagged dependent variable was not significant when added to the models and that various specification tests found no faults. However, the sample size is small with just 16 observations.

For tobacco consumption by smokers the three functional forms previously considered for per adult consumption were employed again. The results are shown in Table 7. In all three models the price effect was statistically significant (just below the critical value in the constant elasticity model),

1. These are based on OLS estimation. Theoretically, GLS ought to be more efficient because the variance of the proportion contains a heteroscedastic component $p(1-p)/n$, where p is the true proportion in a particular year and n is the sample size on which the proportion is based, that is the number of survey respondents. But no detectable changes to coefficients or standard errors results from GLS, probably because $n = 5,000$.

although for the logistic model there is an intrinsic relationship between budget share and price and the price elasticity of consumption is the relevant quantity. The income effects are not significant, again excluding the intrinsic relationship in the case of the logistic. Although a dummy variable, allowing, as before, a change in intercept at 1984-85, was significant, the time trend was not. Indeed, it had the "wrong" sign in all equations, so it seems that health education and other measures do not reduce the consumption of confirmed smokers. From Table 6, these factors seem to reduce recruitment to the ranks of smokers and encourage desertion from the ranks, but the entrapped smoker responds only to price and even then the elasticity is low. The value at the mean was about -0.3 for all models and even at the end of the period they differed little. Modifications, including addition of lagged dependent variables, did not give any extra significant results or improved fit.

Table 7: *Tobacco Consumption by Smokers*

Model	Coefficients				Elasticities				R ²	D-W
	p	y	t	D	p _m	p _e	y _m	y _e		
Linear	-218.3 (-2.2)	0.03 (.7)	6.35 (1.6)	-70.1 (-2.5)	-0.31	-0.35	0.18	0.23	0.77	2.8
Log-linear	-0.28 (-2.1)	0.14 (.5)	0.01 (1.6)	-0.12 (-2.7)	-0.28	-0.28	0.14	0.14	0.77	2.8
Logistic	0.82 (5.4)	-0.99 (-3.2)	0.01 (1.7)	-0.14 (-2.7)	-0.28	-0.29	0.15	0.15	0.89	2.7

Notes: T-values are in parentheses. The subscripts m and e correspond to elasticities calculated at the mean and the end of the period. Note that the "mean" is of the sample of 16, not of 31 as in Table 3.

With only 16 observations it is not plausible to expect that a choice between the three models in Table 7 can be made on purely statistical criteria.² From an economic theory standpoint, a model capable of an increasing magnitude of a price elasticity is more plausible than a constant elasticity equation, at least if real prices could become very large. A constant elasticity model would then imply that the budget share would grow to almost all the smoker's income. From a practical viewpoint, however, the models produced such similar elasticity estimates that choosing between models is not crucial and, indeed, some robustness of estimates is comforting.

2. The Box-Cox transformation can nest both the linear and log-linear (though not the logistic) within a family of relationships characterised by a parameter λ , with $\lambda = 1$ and $\lambda = 0$ corresponding to linear and log-linear respectively. The estimated λ turns out greater than unity, which perhaps supports a linear rather than log-linear form, but it is not significantly different from $\lambda = 0$, let alone $\lambda = 1$.

VI DISCUSSION AND CONCLUSIONS

The failure of the rational addiction model, as shown in Table 5, deserves discussion. It might, perhaps, be argued that failure with per adult data could be because per smoker consumption would be more appropriate. But Becker, Grossman and Murphy (1994) used per capita, and not even per adult, data. The model is disputable in that the forms of "rationality" and "addiction" that it embodies are not the only forms possible. While identifying rationality with full evaluation of future consequences is an attractive idea, it is a large assumption to suppose that such evaluation will be adequately represented by the coefficients of future values of variables. The model is not like the rational expectations models that have come to the fore in recent years, which model the formulation of expectations, assuming rational economic behaviour, with the clear appreciation that expectations are not outcomes. Instead, it assumes that smokers have perfect foresight. From a technical viewpoint, these considerations relate to the validity of using future price as an instrument in the two-stage least squares analysis in Becker, *et al.* (1994).

As regards addiction, the idea that a smoker's current consumption depends on that in a previous time period is plausible, but may not imply much for annual data. A smoker may choose to light a cigarette twenty or more times a day. After a price rise, the downward adjustment of the quantity smoked, small though it might be, may indeed occur in stages because of the resistant addiction effect. But the plausible time scale is one of weeks, or even days, and not of years. Certainly, the Irish data showed little evidence of substantial lagged dependent variable effects, even in the case of the per adult analyses of Table 3.

It is true that other authors, mentioned in Section III, found their data supported the Becker-Murphy model. Perhaps situations differ between countries, but it should be remarked that the data used by others were not beyond criticism. By its nature the Becker-Murphy model requires at least three time points to see if past and future values influence current ones, but Chaloupka (1991), for example, had data from single survey interviews with individuals. The interviewees were asked about smoking at the time of the survey, smoking in the previous time period and before that again, but only if their smoking had been declining. So Chaloupka (1991) took current smoking as the "future" value, treated past smoking as the "current" value and *estimated* a "past" value. In this way he generated data to which the Becker-Murphy model could be fitted, but the data are hardly ideal.

Anti-smoking campaigners have cited results from rational addiction models, because of the higher price elasticities and the implied effect on

current consumption of commitments to future price increases. But rational addiction models may actually suit the tobacco industry more than the health agencies. If commencing smokers understand the addictive nature of tobacco and foresee all the consequences of smoking, it is difficult to justify anti-smoking education and legislation on economic grounds, except to the extent that "passive" smoking may have ill-health effects. A case might then be made that the State's role should just be to provide accurate, but non-exhortatory, information on health effects of smoking. The authors mentioned previously have not actually taken the argument that far and have limited the claims of demonstrations of rationality to the "average", or adult smoker, rather than to teenagers. But Viscusi (1992) claims the young behave just as rationally as do adults in making smoking decisions. From a health promotion viewpoint, it may be just as well that the concept of rational addiction embodied in these models has not been found compatible with the Irish data.

There are clear implications of the two equation model, separating participation and consumption, for policy measures aimed at the reduction of smoking. Health education and the other State intervention factors are more important than pricing policy. The latter may reduce the consumption of smokers somewhat, but has no statistically proven impact on the number of smokers. The intervention measures are effective in reducing the number of smokers. The absence of intervention effects on the consumption of smokers may have to do with the nature of addiction to smoking. Unless the smoker can break free, consumption seems to remain near a habitual level, responding only insensitively to price change. Even so, there are implications for excise revenue, which have been discussed by Conniffe (1995).

These findings are compatible with research on the process by which smokers become hooked as teenagers or young adults. Most teenagers seem to experiment with smoking, but only a proportion persist sufficiently to become addicted (O'Connor and Daly, 1985; Grube and Morgan, 1986). Factors such as peer acceptance, self-image and absence of perceived parental disapproval have been reported as important in many publications in the international literature and by Grube and Morgan for Ireland. These depend on exposure and reaction to health education on the one hand, and to tobacco advertising, direct and indirect, on the other (see, for example, Ledwith, 1984; Potts, *et al.*, 1986; Aitken, *et al.*, 1987 and Vickers, 1992). Price and income may well not play a key role, although price may later constrain, to some degree, the quantity consumed by the smoker.

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