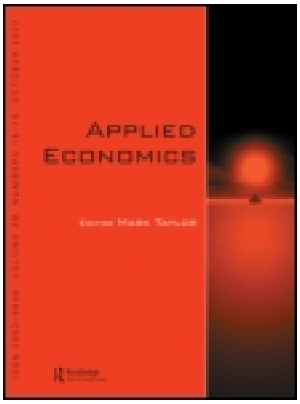

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Will a special tax on tobacco reduce lung cancer mortality? Evidence for EU countries

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This article carrys out a quantitative evaluation of the effects on the health of smokers of increasing a special tobacco tax, using the mortality rate from lung cancer as an indicator. To that end, it estimates two models that relate tobacco consumption, the mortality rate and this special tax, employing data drawn from a sample made-up of 12 EU countries and covering the years 1983–1993. The results show that increasing the special tax is a useful tool for reducing lung cancer mortality. Specifically, it finds that a 10% increase will reduce the lung cancer mortality rate by 1.21% in the first year, with such a reduction implying the avoidance of 1707 deaths in the sample countries.

I. INTRODUCTION

Following the appearance in 1964 of the first official report in the USA that recognized the harmful effects of tobacco consumption on smokers, namely *The Surgeon General's Report on Smoking and Health*, practically every Western government, stimulated by a series of social collectives which demanded public intervention against smoking, began to design and implement a number of policies aimed at reducing such consumption. These public policies included limitations on advertising or on the number of places in which smoking was permitted, information campaigns warning of the harmful effects of tobacco consumption or fiscal regulations that increase the special tax levied on tobacco.

If one concentrates on these fiscal regulations, the principal argument used to justify a specific tax on tobacco consumption is the need to internalize the external costs arising from it. Thus, given that smoking is an obvious determining factor in the appearance of different diseases (bronchitis, cardio-vascular disorders, emphysemas, malignant tumours in the lung, trachea, larynx, oesophagus, etc.), tobacco consumption is associated with the use of medical and health services on the part of smokers. The costs arising from this use obviously constitute an externality that these consumers impose on non-smokers. This justification for a special tax has given rise to a relatively extensive empirical literature, which has traditionally concentrated on analysing the effects of this tax on consumption (Lewit and Coate, 1982; Kao and Tremblay, 1988; Chaloupka, 1991; Becker *et al*., 1994; Chaloupka and Wechsler, 1997). However, little consideration has been given to the effects of this fiscal regulation on smokers' health, albeit with some noteworthy exceptions (Cook and Tauchen, 1982; Moore, 1996).

Therefore, and assuming that governments can limit their populations' health problems by proposing fiscal measures to reduce tobacco consumption, the aim of this article is to make a quantitative evaluation of the effects on smokers' health of increasing the special tobacco tax, using the mortality rate from malignant tumours of the lung, trachea and bronchi (hereafter, mortality rate from lung

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cancer) as an indicator. To that end, this article first formulates one model which relates tobacco consumption with the lung cancer mortality rate, and then quantifies the relationship between such consumption with the special tobacco tax. These models are estimated using a pool of observations for 12 European Union countries covering the period from 1983 to 1993. A joint consideration of these results will enable us to determine whether the fiscal regulation of tobacco consumption is a useful tool for reducing the lung cancer mortality rate. In particular, one simulates the avoidable mortality for the sample countries in a tax scenario which supposes an increase of 10% in the tax.

The rest of the article is organized as follows. Section II describes the statistical information used in the empirical analyses. Section III includes the specifications between tobacco consumption, the mortality rate and the tax. The estimations of the models, as well as the simulations of avoidable mortalities in response to the tax increase, are presented in Section IV. Finally, Section V closes the article with a summary of the main conclusions.

II. DATA

The data used in this study forms a homogeneous pool for 12 EU countries, namely Austria, Belgium, Denmark, Finland, France, Greece, Holland, Ireland, Italy, Spain, Sweden and the UK covering the years 1983–1993.

As regard the variables included in the analysis, the tobacco consumption corresponding to each country was obtained from the Spanish cigarette manufactures, Tabacalera, S.A., whilst the per capita values were calculated by dividing total consumption by the population aged between 16 and 65, with this data being taken from the OECD 'Labour Force Statistics'. The tax rate on tobacco has been calculated by dividing the amount collected, taken from the 'Revenue Statistics of OECD Member Countries' and 'Impôts et Cotisations Sociales' of the OECD and EEC respectively, by the number of cigarettes consumed. This tax rate has been deflated with a 1993 tobacco prices index obtained by dividing the nominal and real cost series of the OECD's 'National Accounts Vol. II'. Both the tax rate and the income have been converted into US dollars using purchasing power parities. The lung cancer mortality rate has been calculated as the weighted average of the standardized mortality rates of men and women from cancer of the lung, bronchi and trachea, as calculated by the WHO. Finally, one has also considered the consumption of alcohol as an exogenous variable, with this consumption being obtained from the Eurostat Yearbooks.

Table 1 shows the typical averages and deviations for all the variables in the observations pool, while Tables 2 and 3 show the same statistical indicators by country and by year, respectively. If one first compares the total values with the figures corresponding to the different countries, one can note the following: Belgium, Holland and the UK show the highest mean values of the standardized mortality rate (per 100 000 inhabitants), 40.85, 40.59 and 39.97, respectively, well above the average figure for the observations pool, 30.9. On the other hand, the countries presenting the lowest values of this variable are Sweden and Spain, with 16.55 and 23.2, respectively. As regards per capita tobacco consumption, one can see that the overall average figure, 2663.5, is easily surpassed by the highest average values, corresponding to Greece, 4313.6 and Spain, 3084.3, while Holland and Sweden are shown to be the countries with the lowest consumption figures, 2043.3 and 2076.3, respectively. With respect to per capita income, France, Austria and Belgium show the highest values, 25 627.5, 25 401.4 and 25 239.2, respectively, whilst the lowest correspond to Greece and Ireland, 11 663.1 and 17 136.1, respectively. The highest taxes on cigarettes appear in Belgium, 0.0840 and the UK, 0.0801, a long way above the average value for the observations pool, 0.0581, while Spain and France levy the lowest taxes, 0.0200 and 0.0443, respectively. Finally, the highest per capita consumption of alcohol appears in France and Spain, 15.94 and 14.36, respectively, whilst the lowest values are to be found in Sweden, 6.60 and Finland, 8.74.

Table 1. *Definition of variables*

Variable	Average (SD)	Definition
T_{pit}	30.9 (7.58)	Standardized mortality rate for cancer of the lung, trachea and bronchi
c_{it}	2663.55 (627.38)	Cigarette consumption per person aged between 16 and 65, and per year
y_{it}	21 905.24 (4449.4)	Income per person aged between 16 and 65 measured by GDP at factor costs expressed in 1993 prices and US dollars
t_{it}	0.0581 (0.018)	Taxes per cigarette measured in 1993 prices and US dollars
a_{it}	11.14 (2.58)	Litres of alcohol consumed per person and per year
pp_{it}	1.5112 (0.0508)	Percentage represented by total population with respect to the population aged between 16 and 65

Table 3 shows the time evolution of the variables considered in the analysis. Here, one can see that the standardized mortality rate has fallen consistently, from the highest values, around 31.5 in the first sample years, down to the lowest, 30.21 in the final year. A similar observation may be made with respect to the per capita consumption of cigarettes, which has decreased consistently from the highest value in the first sample year, 2780.8, to the lowest in the final year, 2551.1. On the other hand, per capita income has clearly been rising, from the lowest figure in the first year, 19 715.7, to the highest in the final year,

Table 2. *Data description by countries*

	Gross mortality rate (%)		Standardized mortality rate (%)		Per capita cigarette consumption		Per capita income		Cigarette tax		Per capita alcohol consumption	
Country	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD
Austria	41.60	1.00	26.68	0.64	2864.2	247.1	25 401.4	1761.9	0.0580	0.0028	12.40	0.25
Belgium	65.39	1.11	40.85	1.38	2450.7	263.2	25 239.2	1963.8	0.0840	0.0130	12.21	0.84
Denmark	62.66	1.63	37.55	0.63	2415.3	108.5	24 635.6	1129.4	0.0765	0.0047	12.07	0.36
Finland	39.41	1.98	28.34	2.63	2118.6	198.5	21 048.7	1519.1	0.0565	0.0037	8.74	0.52
France	37.20	2.25	24.94	0.93	2562.0	50.5	25 627.5	1499.6	0.0443	0.0047	15.94	1.05
Greece	44.69	2.93	27.48	0.74	4313.6	125.5	11 663.1	415.0	0.0460	0.0078	10.10	0.91
Holland	56.89	1.33	40.59	1.67	2043.2	426.4	23 177.7	1483.4	0.0563	0.0133	10.28	0.46
Ireland	43.34	1.39	33.18	1.51	2947.3	170.9	17 136.1	2276.6	0.0650	0.0074	9.82	0.67
Italy	50.18	3.00	31.57	0.77	2548.7	203.9	23 536.7	1852.5	0.0552	0.0040	12.13	1.77
Spain	33.46	4.27	23.20	1.79	3084.3	187.2	17 361.6	1520.1	0.0200	0.0088	14.36	1.19
Sweden	31.34	0.88	16.55	0.49	2076.3	212.0	24 744.4	1213.1	0.0559	0.0033	6.60	0.14
UK	69.53	2.36	39.97	2.31	2538.5	105.9	23 291.1	1748.6	0.0801	0.0020	9.13	0.23

Table 3. *Data description by years*

	Gross mortality rate (%)		Standardized mortality rate (%)		Per capita cigarette consumption		Per capita income		Cigarette tax		Per capita alcohol consumption	
Year	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD
1983	46.26	14.20	31.18	8.91	2780.8	527.4	19 715.7	4041.6	0.0575	0.0218	11.74	3.70
1984	47.13	13.88	31.52	8.73	2754.6	598.1	20 079.0	4108.0	0.0613	0.0226	11.42	3.28
1985	47.73	13.91	31.59	8.67	2715.3	704.1	20 503.4	4176.9	0.0591	0.0226	11.43	2.91
1986	47.31	13.69	31.12	8.46	2659.0	690.8	20 908.5	4339.5	0.0608	0.0202	11.22	2.84
1987	47.82	13.38	31.06	7.98	2628.5	730.8	21 383.5	4387.0	0.0585	0.0218	11.18	2.74
1988	48.67	13.23	31.45	8.07	2613.7	626.3	22 103.0	4466.0	0.0576	0.0189	11.05	2.40
1989	48.27	12.56	30.80	7.59	2622.9	613.0	22 848.8	4470.8	0.0576	0.0180	11.03	2.31
1990	48.25	12.30	30.55	7.18	2654.0	601.1	23 393.5	4578.8	0.0563	0.0163	11.06	2.25
1991	48.27	11.99	30.25	6.83	2680.7	658.9	23 345.7	4566.6	0.0567	0.0157	10.89	2.10
1992	48.68	11.72	30.27	6.76	2638.6	634.6	23 415.9	4649.1	0.0570	0.0130	10.82	2.15
1993	49.31	12.02	30.21	7.04	2551.1	728.6	23 260.7	4592.5	0.0574	0.0125	10.78	2.22

23 260.7. With regards to special taxes on cigarettes, one can note a decreasing trend, although with oscillations, given that the highest values appear in the earlier sample years and the lowest in the final year. Finally, per capita alcohol consumption, like that of cigarettes, shows a clearly downward trend, from the highest value in the first sample year, 11.74, to the lowest in the final year, 10.78.

III. METHODOLOGY

It is well known that tobacco consumption is a determining factor in the appearance of lung cancer and, therefore, has a significant influence on mortality from this illness. Thus, the more tobacco a smoker has consumed during his/her lifetime, the greater the probability of this individual suffering from lung cancer. It is also known that similar levels of consumption do not cause the same effects on the health of all smokers, since each individual has a maximum value or threshold which indicates the maximum amount of tobacco that may be consumed before that smoker dies.

The threshold of individual consumption, u, depends first on the physical characteristics of the person, in the form of the initial state of health that he/she was born with, and second, on his/her lifestyle, e.g. eating habits, sporting activities, living with smokers, etc. Thus, given that this threshold is different for each individual, and although it cannot be known a priori, it is assumed that it adjusts to a particular probability distribution, $F(x) = Pr(u \leq x)$, with x being the accumulated consumption from birth up to the present. Therefore, $F(x)$ indicates the probability of a smoker exceeding his/her threshold, and consequently dying from lung cancer. If one assumes that individuals, with a life span of T periods, consume at a constant annual rate, c, then at any given moment of their lives, t, the accumulated consumption will be ct. Consequently, the probability $F(ct)$ will enable us to calculate the number of people in a generation who die from lung cancer. Thus, if one assumes that N individuals are born each year, then the total number of persons, of those born t years ago, who have died for this reason will be $NF(ct)$.

One can also calculate the rate of individuals in one generation who reach the threshold and, therefore, die at a particular moment in time. To that end, one first take the derivative of the number of people who die with respect to time, thereby obtaining the number of individuals who reach the threshold at a given moment. One can then divide this value by the number of people in that generation; in other words, $T_g(t) = cf(ct)$, where f is the function of the distribution density. Next, one calculates the average rate of individuals who reach the threshold for all generations from period *0* up to T, that is to say, the whole population, by integrating between these two limits and dividing by T:

$$T_p = \frac{1}{T}\int_0^T T_g(t)\,dt = c\frac{1}{T}\int_0^T f(ct)\,dt \tag{1}$$

On the basis of this framework, one specifies an empirical formulation that explains the logarithmic of the mortality rate in terms of tobacco consumption, per capita income, alcohol consumption (where this tries to capture the accumulation of risk arising from the simultaneous consumption of both substances), the proportion of the total population with regard to the population between 15 and 65 years old, and finally, a set of dummy variables which include specific fixed effects for each country and year:

$$\begin{aligned}\log T_{pit} = \beta_0 + \beta_1 \log c_{it} + \beta_2 \log y_{it} + \beta_3 \log a_{it}\\ + \beta_4\, pp_{it} + \upsilon_i + \lambda_{it} + e_{it}\end{aligned} \tag{2}$$

where T_{pit} is the mortality rate in country i in the period t, c_{it} is the per capita consumption of tobacco, y_{it} is the per capita income, a_{it} is the per capita consumption of alcohol, pp_{it} is the proportion of the population, υ_i is invariant over time for the country i, λ_t is the specific effect of the general period t for all countries and, finally, e_{it} is the error term. In the specification of the stochastic properties of the error term two components are assumed, namely heteroscedasticity and first-order autocorrelation, given that dealth from lung cancer is an independent event for each person and, second, that the mortality rate has a inertia component.

Before proceding to the estimation of this functional form, one important question to be considered is the exogenous nature of the explanatory variables. In particular, one is interested in checking if tobacco consumption is exogenous with regard to the mortality rate; in other words, if there is a feedback effect whereby smokers modify their consumption in response to variations in the observed mortality rate. Thus, to test whether there is a unidirectional causality, the Granger (1969) test is used, whose suitability for detecting possible feedback processes has been confirmed by two Monte Carlo studies (Geweke *et al*., 1979; Guilkey and Salemi, 1982).

Next, in order to analyse how the demand for tobacco evolves, a model that directly relates the logarithm of per capita tobacco consumption with the present and past values of both the special tax and the per capita income is considered:

$$\log c_{it} = \Sigma_j \alpha_{jit} t_{i\,t-j} + \Sigma_j \beta_j y_{i\,t-j} + \gamma a_{it} + \upsilon_i + \lambda_t + e_{it} \tag{3}$$

where t_{it} is the tax per cigarette. Given the time component of the observations, it is to be expected that the error term will show a first order autoregression process.

IV. EMPIRICAL RESULTS

First the exogeneity of tobacco consumption was tested with respect to the mortality rate by using the Granger test (Table 4). Here, one can note that the coefficient accompanying the mortality rate is non-significant, which allows us to accept the exogenous nature of the consumption. Thus, the following step is to estimate the mortality Equations 2, with the results appearing in Table 5. In both specifications, with and without alcohol consumption, one can observe that both tobacco consumption and income have a positive and significant effect on the lung cancer mortality rate. One also finds that the elasticity of the mortality rate with respect to current consumption appears

Table 4. *Exogeneity of tobacco consumption with respect to the mortality rate*

	constant	$\log c_{it-1}$	$\log c_{it-2}$	$\log T_{pit-1}$	$\log y_{it}$
$\log c_{it}$	1.774*	0.921*	−0.167	−0.187	0.021*
	(2.101)	(8.88)	(−1.619)	(−1.217)	(2.432)

Notes: Asymptotic t-statistics in parentheses.
*Indicates individual significance at the 5% level.

Table 5. *Estimation of the mortality model*

Variables	$\log T_{pit}$	
$\log c_{it}$	0.3265*	0.3409*
	(6.503)	(5.663)
$\log y_{it}$	0.4883*	0.5180*
	(5.329)	(5.296)
$\log a_{it}$	0.0538	–
	(0.626)	–
pp_{it}	−0.7364*	−0.6979
	(−2.221)	(−1.689)
Corrected R^2	0.9948	0.9941
D–W	1.5696	1.2947

Notes: Asymptotic t-statistics in parentheses.
*Indicates individual significance at the 5% level.

between 0.32 and 0.34. The explanation of these positive signs is obvious. With respect to the second variable, one interpretates that aspects which appear as reflections of increases in income, for example, a more sedentary lifestyle, also increase the lung cancer mortality rate. Furthermore, the parameter corresponding to alcohol consumption is also positive, although non-significant at the 5% level. Finally, the model has a very good explanatory power, with a corrected R^2 of 0.99.

Once again, the estimation of Equation 3 will only be valid if the explanatory variables are exogenous with regard to consumption. In this regard, the results of the Granger test (Table 6) confirm the exogenous nature of the special tax. Table 7 shows the estimation results of the consumption model in its three versions. The most relevant result is the negative and significant effects of the special tax on consumption, with a current elasticity, measured in mean values, of between −0.3816 and −0.3935, whereas the lagged elasticity appears between −0.1497 and −0.1690. Moreover, one can also detect the significant complementary nature between tobacco and alcohol, which implies that the special tobacco tax also reduces alcohol consumption.

After having obtained the effects of the special tax on consumption and, in turn, of consumption on the mortality rate, one can now combine these effects in order to forecast the impact of fiscal-based health policies aimed at reducing tobacco consumption and, thus, the lung cancer mortality rate. Specifically, a simulation exercise was carried out which will enable one to calculate the avoidable mortality that results from a given increase in the tax. Thus, if one initially considers a 10% increase in the tobacco tax, the estimations indicate that the mortality rate should fall by 1.21%, with this figure being obtained by multiplying the elasticity of the mortality rate with respect to consumption, 0.32, by the elasticity of consumption to tax, −0.38. Finally, this percentage allows us to conclude that a 10% increase in the tax, *ceteris paribus*, would lead to the avoidance of 1707 deaths in the 12 sample countries during the first year 1993 (Table 8).

Table 6. *Exogeneity of the tax with respect to tobacco consumption*

	constant	t_{it-1}	t_{it-2}	$\log c_{it-1}$	y_{it}
t_{it}	0.010	0.638*	−0.116	0.002	−0.003
	(0.151)	(6.708)	(1.231)	(0.214)	(−0.532)

Notes: Asymptotic t-statistics in parentheses.
* Indicates individual significance at the 5% level.

Table 7. *Estimation of the consumption model*

Variables	$\log c_{it}$		
y_{it}	−0.0125	−0.0107	–
	(−1.666)	(−1.522)	–
y_{it-1}	0.01173	–	–
	(0.706)	–	–
t_{it}	−6.3982*	−6.3963*	−6.7729*
	(−4.528)	(−4.538)	(−4.856)
t_{it-1}	−2.7693*	−2.5761*	−2.6821*
	(−2.075)	(−1.977)	(−2.048)
a_{it}	0.0376*	0.0368*	0.03648*
	(3.238)	(3.195)	(3.142)
Elasticity (current)	−0.3817	−0.3816	−0.3935
Elasticity (lagged)	−0.1690	−0.1497	−0.1558
Corrected R^2	0.9976	0.9976	0.9976
D–W	1.651	1.617	1.607

Notes: Asymptotic t-statistics in parentheses.
* Indicates individual significance at the 5% level.

Table 8. *Avoidable mortality in 1993*

	Population (miles)	Mortality rate (%)	Avoidable mortatily in 1993
Austria	7993	41.38	40
Belgium	10 084	66.00	81
Denmark	5189	66.03	42
Finland	5066	37.43	23
France	57 654	40.37	283
Greece	10 380	49.00	62
Holland	15 290	56.34	105
Ireland	3563	45.02	20
Italy	57 070	54.18	376
Spain	39 086	38.53	183
Sweden	8718	31.28	33
UK	58 293	64.82	459
Total	278 386		1707

V. SUMMARY AND CONCLUSION

This article has carried out an analysis of whether a special tobacco tax would prove to be an efficient tool when seeking to reduce lung cancer mortality.

The results obtained show an elasticity of the mortality rate with regard to per capita current consumption of 0.32 and a elasticity of consumption with regard to the current tax of −0.38. In the light of these figures, a 10% increase in the tax would reduce the lung cancer mortality rate by 1.21% in the first year, implying that 1707 deaths will be avoided for the twelve EU countries in 1993. Thus, the special tobacco tax would indeed appear to be a useful tool for reducing long cancer mortality related to tobacco consumption.

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REFERENCES

Becker, G. S. and Murphy, K. M. (1994) A theory of rational addiction, *Journal of Political Economy*, **96**, 675–700.

Chaloupka, F. (1991) Rational addictive behavior and cigarette smoking, *Journal of Political Economy*, **99**, 722–42.

Chaloupka, F. and Wechsler, H. (1997) Price, tobacco control policies and youth smoking, *Journal of Health Economics*, **16**, 359–73.

Cook, P. J. and Tauchen, G. (1982) The effect of liquor taxes on heavy drinking, *Bell Journal of Economics*, **13**, 379–90.

Geweke, J., Meese, R. and Dent, W. (1979) Comparing alternative tests of causality in temporal systems: analytical results and experimental evidence, University of Winsconsin-Madison, Social Systems Research Institute, Workshop Series N° 7928.

Granger, C. W. J. (1969) Investigating causal relations by econometric models and cross-spectral methods, *Econometrica*, **37**, 24–36.

Guilke, D. and Salemi, M. K. (1982) Small sample performance of three tests for Granger-causal-ordering in a bivariate stochastic, *Review of Economics and Statistics*, **4**, 668–79.

Kao, K. and Tremblay, V. J. (1988) Cigarette health scare excise taxes, and advertising ban: comment, *Southern Economic Journal*, **54**, 770–75.

Lewit, E. M. and Coate, D. (1982) The potential for using excise taxes to reduce smoking, *Journal of Health Economics*, **1**, 121–45.

Moore, M. J. (1996) Death and tobacco taxes, *Rand Journal of Economics*, **27**, 415–28.