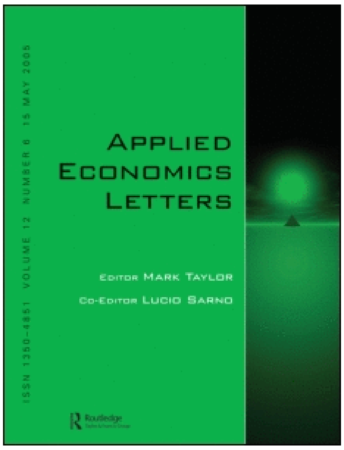

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Testing for the rational addiction hypothesis in Spanish tobacco consumption

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This paper tests whether tobacco consumption generates addiction in Spanish people and, if so, then whether such addiction can be explained in the context of rational addiction theory. To that end, time-series data of per-capita consumption and prices of tobacco during the period 1964 to 1995 are employed. The results show the addictive and rational character of Spanish tobacco consumption, which implies that smokers fall into addiction after a maximization process of the utility that was obtained during their total lifetime, taking into account the future consequences of current decisions.

I. INTRODUCTION

The works which analyse the consumer behaviour of individuals usually assume the rational hypothesis of lifetime utility maximization, save for the first studies devoted to addictive goods which supposed that such consumption was derived from irrational behaviour (see Elster 1979; Winston 1980). However, subsequent studies have raised the possibility that the behaviour of agents who consume addictive goods could be considered as rational, in the sense of involving forward-looking maximization with stable preferences (e.g. Becker and Murphy, 1988; Becker *et al.*, 1991, 1994; Chalopukpa, 1991; Waters and Sloan, 1995; Olekalns and Bardsley, 1996; Grossman and Chalopukpa, 1998; Suranovic *et al.*, 1999). In this context, the rational addiction model proposed by Becker and Murphy (1988) is based on a behaviour that maximizes the utility obtained during the total lifetime of individuals. This model incorportates the dependence between the current and the past consumption of addictive goods, which implies that recognition is given to the existence of notions of tolerance, reinforcement and withdrawal. Tolerance suggests that a given level of consumption yields less satisfaction, as past cumulative consumption is higher. Reinforcement implies a learned response to past consumption and, finally, withdrawal refers to a negative physical reaction and other reductions in utility, associated with the cessation or interrruption of consumption.

The objective of this paper is to test whether tobacco consumption generates addiction in Spanish people and, if this is the case, then whether such addiction can be explained in the context of rational addiction theory. In other words, we examine if the consumer falls into addiction after a maximization process of the utility that was obtained during his total lifetime, taking into account the future consequences of current decisions or, by contrast, if the consumer becomes addicted because he does not evaluate the future consequences of current choices. In this line, a non-separable intertemporal utility function is considered in which tobacco addiction incorporates the dependence between current decisions and past decisions, thus permitting the inclusion of the earlier-cited notions of tolerance, reinforcement and withdrawal. The maximization of such a utility function, subject to the corresponding budget restriction, allows us to obtain a demand function in which current consumption depends on lag and lead consumption and on current price. This demand function is

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then estimated using Spanish time-series data of per-capita consumption and prices during the period 1964–1995.

The organization of the paper is as follows. Section II develops the theoretical framework of rational addiction, deriving the expression of the demand function. Section III is devoted to the data and the estimation procedure. In Section IV the empirical results are described and, finally, Section V summarizes the main conclusions of the paper.

II. THEORETICAL FRAMEWORK

The rational addiction model for tobacco considers a utility function for consumers which incorporates the addiction that is given by the dependence between the current utility and the past consumption of the addictive good. Moreover, it is assumed that individuals are rational because their objective is to maximize the utility obtained during all their lifetime. In this context, at any givent moment in time, consumers' utility is assumed to be a function of health, $H(t)$, the relaxation produced by addictive consumption, $R(t)$, and a composite of other consumption goods, $Z(t)$, that is to say, $U(t) = U[H(t), R(t), Z(t)]$. It is assumed that this utility function is concave, and has positive first derivates and negative second derivates.

The first variable, health, is assumed to be a function of some market goods, such as medical care, and the individual's own time spent, for example, on exercise, $M(t)$. These inputs have positive but diminishing effects on health, which is also affected by the cumulative past consumption of the addictive stock, $S(t)$. The stock accumutation process is described by a simple investment function, $\dot{S}(t) = C(t) - \delta\dot{S}(t)$, where $\dot{S}$ is the rate of change over time in S, C is the consumption of the addictive good and δ is the constant depreciation rate. Cigarette consumption at time t can be thought of as a gross investment in the addictive stock. Therefore, the health production function can be expressed as $H(t) = H[M(t), S(t)]$, with $H_M > 0, H_{MM} < 0, H_S < 0$ and $H_{SS} < 0$. Relaxation, that is to say, the psychological benefits of smoking, is produced by the addictive good, $C(t)$, and the addictive stock, $S(t)$. Therefore, $R(t) = [C(t), S(t)]$, with $R_C > 0$, $R_{CC} < 0$, $R_S < 0$, $R_{SS} < 0$ and $R_{CS} > 0$. Increased consumption has a positive effect on the production of relaxation, whereas higher past consumption has a negative effect. This assumption incorporates the notion of tolerance into the model. To capture reinforcement effects in consumption, the marginal productivity of cigarette consumption in the production of relaxation is assumed to increase with the level of the addictive stock. Finally, the composite good is produced using inputs, $X(t)$, which include market goods and the individual's own time, with each of these assumed to have positive but diminishing marginal productivity, that is to say, $Z(t) = Z[X(t)]$, where $Z_X > 0$ and $Z_{XX} < 0$. In summary, an instantaneous utility function is derived, $U(t) = U[C(t), S(t), Y(t)]$, where $Y(t)$ is a vector that includes inputs into the production of the composite good and health.

Under the assumption of a time-additive utility function, with a length of life equal to T and a constant rate of time preference, σ, $Y(t)$ is treated as a composite which is considered as numeraire, and where $P_C(t)$, r and A_0 are the money price of the addictive good, the constant market interest rate and the discounted value of lifetime income and assets, respectively. Thus, rational behaviour implies the maximization of the lifetime utility function, subject to the lifetime budget constraint and the simple investment function:

$$\begin{aligned}&\text{Max. } U = \int_0^T e^{-\sigma t} U[Y(t), C(t), S(t)]dt \\ &\text{s.t.} \int_0^T e^{-rt}[Y(t) + P_C(t)C(t)]dt \le A_0 \\ &\dot{S}(t) = C(t) - \delta S(t)\end{aligned} \tag{1}$$

On the basis of the above theoretical framework, a demand function is derived for the addictive good using a quadratic utility function in the difference between present consumption and addiction stock as an indicator of past consumption (Pollak, 1970). It is assumed that first derivatives are positive and that the utility function is concave with negative second derivatives:

$$\begin{aligned}U(t) = {}& \frac{U_{CC}}{2}[C(t) - S(t)]^2 + \frac{U_{YY}}{2}[Y(t)]^2 \\ &+ u_C[C(t) - S(t)] + u_Y[Y(t)] + u_{CY}[C(t) \\ &- S(t)][Y(t)]\end{aligned} \tag{2}$$

This function clearly shows the effect of consumption on utility. The addicted consumer obtains a disutility if he does not consume a minimum quantity, S(t). Moreover, we can observe that the disutility associated with withdrawal increases with the stock of addiction, and further that when an individual finishs his consumption, the addiction stock does not fall instantaneously to zero. It can be seen that marginal utility increases with the addiction stock, which is a necessary condition for addiction ($U_{CC} < 0$).

Therefore, the discrete maximization of the finite lifetime utility 2, considering that the individual's rate of time preference is equal to the market rate of interest, implies solving (see, for details, Becker and Murphy, 1988):

$$\begin{aligned}&V(A_0, S(0), P_C) = K + \text{Max}_C \sum_0^T (1+\sigma)^{-t} F[C(t), S(t)] \\ &\text{s.t.} S(t+1) - S(t) = C(t) - \delta S(t)\end{aligned} \tag{3}$$

where:

$$K = \mu A_0 - \frac{(\mu - U_Y)^2}{2\sigma U_{YY}}(1 - e^{-\sigma T}) \quad (4)$$

$$F[C(t), S(t)] = \alpha_C[C(t)] + \alpha_S[S(t)] + \frac{\alpha_{CC}}{2}[C(t)]^2 + \frac{\alpha_{SS}}{2}[S(t)]^2 + \alpha_{CS}[C(t)S(t)] - \mu P_C(t)C(t) \quad (5)$$

and with μ being the marginal utility of income.

The first-order condition with respect to $C(t)$, and assuming that the addiction stock constitutes the consumption of the past period, allows us to derive the following demand function (see Chaloupka, 1991; Labeaga, 1993; Becker *et al.*, 1994; Cameron, 1997; Grossman and Chaloupka, 1998):

$$C(t) = c_0 + c_1 C(t-1) + c_2 C(t+1) + c_3 P_C(t) \quad (6)$$

where

$$c_0 = \frac{1}{M}\left[\frac{1}{(1+\sigma)}\alpha_S + \alpha_C\right], c_1 = \frac{1}{M}\alpha_{CS}, c_2 = \frac{1}{(1+\sigma)M}\alpha_{CS}, c_3 = \frac{-\mu}{M}$$

and, finally,

$$M = \left[-a_{CC} - \frac{1}{(1+\sigma)}a_{SS}\right]$$

This equation indicates that current price affects current consumption negatively, whereas past consumption and future consumption affect it positively. Moreover, the marginal utility of income, μ, only appears as a multipying factor in the current price coefficient, that is to say, an increase in the marginal utility of income will imply a greater increase in the price coefficient. This means that people with less marginal utility of income are less sensitive to price changes, which, in turn, suggests that rich people, with a lower μ, will be less sensitive to prices changes and people with lower income, that is to say, with greater μ, will be more sensitive.

On the basis of such a function, we can easily test if consumers' behaviour is addictive and, in this case, if it is rational or myopic. Thus, a good will be addictive if its consumption is complementary in several periods, that is to say, if its consumption in different periods is positive and significantly related. Moreover, the test of rational addiction, as compared to myopic addiction, consists in proving whether consumers take the future into account when making their own current decisions. Thus, myopic demand is only backward-looking, whilst rational demand is both backward-looking and forward-looking. Finally, the rational model implies that the past period has more influence over current consumption than the future period.

III. DATA AND RESULTS

Demand Equation 6 is estimated using tobacco time-series from 1964 to 1995 which have been obtained from the Department of Planning and Economic Studies of the Spanish national tobacco company, Tabacalera S.A. We use the sales of cigarettes in millions of packets as the indicator of tobacco consumption, obtaining the per-capita variable by dividing consumption between the population that is older than 15. The price of tobacco will be a price index obtained by dividing the nominal price between the national consumer price index (base year 1995).

Given the time horizon, it is interesting for the model to take into account the impact of Government regulatory changes on tobacco consumption by way of dummy variables. In particular, several new variables are included. The first, $T78$ ($=0$ until 1977, $=1$ from 1978), is derived from a regulation which limits tobacco advertising. The second, $T79$ ($=0$ until 1978, $=$ time trend from 1979), incorporates improvements in the quality and presentation of the good. Finally, the third and fourth variables, $T82$ ($=0$ until 1981, $=1$ from 1982) and $t88$ ($=0$ until 1987, $=1$ from 1988), establish restrictions on the sale and consumption of tobacco. Thus, the resulting stochastic demand function is:

$$C(t) = c_0 + c_1 C(t-1) + c_2 C(t+1) + c_3 P_C(t) + t_{78}T78 + t_{79}T79 + t_{82}T82 + t_{88}T88 + u(t) \quad (7)$$

This equation implies the endogeneity of past and future consumption, which, in turn, suggests the instrumental variables method, using the independent variables as well as four lead and lag prices, as instruments (Chaloupka, 1991; Labeaga, 1993; Becker *et al.*, 1994; Waters and Sloan, 1995; Olekalns and Bardsley, 1996; Grossman and Chaloupka, 1998).[1]

Table 1 shows the results of the estimation of the demand equation imposing different values of the time preference rate, 5%, 10% and 20%. These results are presented after accepting the use of this new information by way of the Wald test, given that the three particular values, 0.3647, 0.3965 and 0.4597, are all lower than the corresponding critical value of the chi-square distribution at the 5% level of significance, $^2(1)_{0.05} = 3.84$. With respect to the estimated parameters, we can first show that all the parameters of consumption and prices are individually significant at the 5% level. Secondly, we can note that consumption in different periods is complementary. Thus, the parameter of past consumption is positive for the three

[1] Very similar results are obtained using two, three or five lead and lag prices.

Table 1. *Estimations of the demand equation*

	5%	10%	20%
c_0	0.1675*	0.1675*	0.1675*
	(6.221)	(6.191)	(6.139)
$c_1C(t-1)$	0.1543*	0.1577*	0.1640*
	(2.134)	(2.123)	(2.100)
$c_2C(t+1)$	0.1469*	0.1434*	0.1367*
	(2.134)	(2.123)	(2.100)
$c_3P_C(t)$	−0.00076*	−0.00076*	0.00076*
	(−6.571)	(−6.545)	(−6.497)
$t_{78}T78$	−0.0106*	−0.0106*	−0.0106*
	(−3.612)	(−3.606)	(−3.594)
$T_{79}T79$	0.0044	0.0044*	0.0044*
	(5.344)	(5.296)	(5.207)
$t_{82}T82$	0.0038	0.0038	0.0040
	(0.991)	(1.009)	(1.044)
$t_{88}T88$	−0.0101*	−0.0100*	−0.0100*
	(−2.637)	(−2.619)	(−2.586)
$\bar{R}^2$	0.9430	0.9428	0.9425
Wald	0.3647	0.3965	0.4597
Sargan	0.0021	0.0021	0.0022
Breusch–Godfrey	−0.3729	−0.3713	−0.3675

Notes: Values within parentheses are *t*-rates. * Statistically significant at the 5% level.

rates of time preference, 0.1543, 0.1577 and 0.1640, respectively, which implies the addictive character of tobacco, whereas the coefficients of future consumption, 0.1469, 0.1434 and 0.1367, are also positive, which reflects the rationality of individual behaviour. Moreover, the current prices have the expected negative sign, −0.00076 in all three situations. We can further observe that the past consumption parameter is always higher than the future consumption coefficient, as the rational addiction model predicts. Therefore, we can affirm that our three estimations support the addictive rational hypothesis of Spanish tobacco consumption. With respect to the dummy variables, we can note that significant parameters have the expected sign, that is to say, legal restrictions on advertising and sales imply a fall in tobacco consumption, as shown by the negative signs of t_{78} and t_{88}, whereas improvements in the quality and presentation of the good implies a positive sign of the parameter t_{79}.

After presenting the estimated parameters, we show the degree of fit and some specification tests. With respect to the former, we can observe the excellent fit as confirmed by the high $\bar{R}^2$ values, 0.94 in all three cases. As regards the specification tests, we have first tested the validity of the instruments using the Sargan statistic. The particular values for the three cases, 0.0021, 0.0021 and 0.0022, respectively, are lower than the critical value of the distribution, $\chi^2(7)_{0.05} = 14.1$, and, therefore, we can accept their validity. Secondly, we have also tested and rejected the existence of first-order autocorrelation using the Breusch–Godfrey test, given that all the three values, −0.3729, −0.3713 and −0.3675, are lower than the asymptotic critical value, $t_{0.05} = 1.96$.

IV. CONCLUSIONS

This paper has tested whether tobacco consumption in Spain during the period 1964 to 1995 was addictive in Spain and, if so, whether such addiction can be explained by the rational addiction theory. To that end, we have started from a non-separable intertemporal utility function which includes the notions of tolerance, reinforcement and withdrawal. The restricted maximization of this utility function has allowed us to derive a demand function which expresses current consumption in terms of past and future consumption, as well as the current price. This demand function has been estimated by the instrumental variables method, using Spanish time-series of per-capita consumption and prices.

The results are in accord with the Becker and Murphy (1988) model of rational addiction. First, the estimation of the demand function reveals the addictive character of tobacco consumption, deriving the positive effect that past consumption has on current consumption. Secondly, it was found that this addiction is not the result of a myopic consumer behaviour, but rather of the maximization of total utility, implying that rational consumers consider the future effects of their current decisions.

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