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Addiction and the Interaction between Alcohol and Tobacco Consumption

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Abstract - This paper adopts a multi-commodity habit formation model to study whether unhealthy behaviours are related, i.e. whether there are contemporaneous and inter temporal complementarities in Italian consumption of alcohol and tobacco. Own and crossprice elasticities, as well as the income elasticities, are calculated from the parameters of a semi-reduced system estimated on aggregate annual time series for alcohol and tobacco expenditures over the period 1960-2002. Own price elasticities are negative and tobacco appears to be more responsive than alcohol demand, although both responses are less than unity. Cross price elasticities are also negative and asymmetric showing that alcohol and tobacco are complements. Whereby a ”double dividend” could then be exploited, because public policy needs to tackle the consumption of one good only to control the demand of both. The asymmetry in the values of the cross price elasticities coupled with the relative magnitude of the own price responses suggest that the optimal strategy for maximizing public revenues through increases in ”sin” goods excise taxation would be to raise alcohol taxation more than tobacco. Finally, past consumption of one addictive good does not significantly reinforce current consumption of the other addictive good.

Keywords: addiction models; sin goods; GMM estimator;
JEL Classification : D12, C32

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1 Introduction

Since 1992, the World Health Organization (WHO) has advocated a combined approach to reduce harm resulting from the use of alcohol, tobacco and illegal drugs. To this aim, the European Parliament has identified the main initiatives to be taken within the European Union (EU) to modify individual behaviours related to harmful consumption of alcohol, drugs, food and cigarettes. In Italy both alcohol and tobacco demand have followed a decreasing trend since 1985. However a further reduction of both is required as a measure to reduce the public health care costs implied by their negative health consequences and the additional negative externalities their consumption and addiction may cause such as effects on crime, on injuries caused in motor vehicle accidents and on labour market achievement. There is a large number of studies investigating the determinants of alcohol and tobacco demand separately, but few of them have dealt with their interaction explicitly recognizing their addictive nature (see for instance Goel and Morey (1995), Decker and Schwartz (2000), Bask and Melkersson (2004), Picone et al. (2004), Fanelli and Mazzocchi (2004)). Moreover, except for Bask and Melkersson and Fanelli and Mazzocchi, empirical papers are usually not based on any formal theoretical framework.

When modelling the demand for a single addictive good, one of the most popular framework is the rational addiction (RA) model proposed by Becker and Murphy (1988), which under a quadratic utility function leads to a simple linear specification with testable hypotheses. The two key elements in their analysis are the interdependency of past, current and future consumption, which characterizes addictive goods, and the assumption of individual rationality, that is, of far-sighted consumers who can foresee the consequences of their current actions.

The purpose of this paper is to test an extension of the rational addiction model that includes consumption of two addictive goods: alcohol and tobacco. There are two main reasons for doing this: the first is to investigate their contemporaneous substitutability or complementarity. Public policies, in many countries, have focused on cigarettes and liquor as prime targets for excise taxation for at least two reasons: consumption reduction and revenue generation. Information on the way in which these "sin" goods are related, given by the cross price elasticities of demand, may allow a better coordination of these public policies. If they are complements for instance, we could obtain a reduction in consumption of both goods by raising the price of just one of them. On the other hand, if the two are substitutes, measures aimed at reducing one of them could produce the undesired effect of reinforcing the other good's consumption. Stated differently, it may not be sufficient to consider the use of addictive substances separately to design proper policy guidance, such as the optimal level of taxation, the effects of different forms of regulation and the impacts of legalization (Palacios-Huerta, 2003, p.18).

A second aim of the paper is to study whether there is an inter temporal relationship between these two goods, because inter temporal complementarity, for instance, could be interpreted as evidence of a gateway effect. There now exist a bulk of empirical research (Kandel, 1975; Pacula, 1997; 1998; Kenkel et al., 2001), suggesting the so called "gateway hypothesis": past consumption of alcohol or cigarettes (legal drugs) could reinforce current use of illegal addictive substances. The same effect can be thought to apply to two legal substances: alcohol (tobacco) use could increase the likelihood of consuming tobacco (alcohol). An implication of the gateway hypothesis is that conventional estimates of the optimal tax on alcohol or cigarettes may be biased downwards, because they ignore the inter temporal relationship between the two. Another implication is that if alcohol, for instance, is a gate to tobacco consumption, effective measures of reduction of the former could mitigate initiation of the latter. If there is sequencing in the use of these two commodities and if such sequencing is causal in nature, then public policy may be effective at reducing the demand of one of the two by raising the marginal cost of the initiation drug.

Our estimates refer to multi-commodity addiction with a non common habit stock and are based on time series of alcohol and tobacco expenditures in Italy from 1960 to 2002. Since we use aggregate data, a battery of diagnostic tests takes into account some of the warnings put forward by Auld and Grootendorst (2004) concerning the estimation of RA models with this kind of data.

The paper is structured as follows: section 2 briefly reviews the existing literature on the relationship between alcohol and tobacco consumption; section 3 explains the rationale for a common versus non common habit stock in modeling the demand functions; in section 4 we present the theoretical model; the empirical strategy and the estimation results are described in section 5 and 6; section 7 concludes.

2 Previous Studies

There is a large literature investigating the demand for alcohol and cigarettes separately. More realistically, these behaviours are jointly determined, but few empirical works have analysed these coaddiction models. They include: Jimenez and Labeaga (1994); Dee (1999); Decker and

Schwartz (2000); or their contemporaneous and inter temporal interdependence: Jones (1989); Goel and Morey (1995); Bask and Melkersson (2004); Picone, Frank and Sloan (2004) and Fanelli and Mazzocchi (2004). Moreover, most of these empirical papers on multiple addictive goods are usually not based on any formal theoretical framework even though multiple habits and addictions seem to be the rule rather than the exception[1] and the relevance of the issue has been stressed in the literature (Palacios-Huerta, 2003, p. 4).

Decker and Schwartz (2000) consider two separate static demand equations for alcohol and cigarettes where each equation includes, among the explanatory variables, the price of both goods. They use individual level data from 45 states in the US from 1985 to 1993 taken from the Behavioural Risk Factor Surveillance System (BRFSS) and estimate a model which separates participation from consumption. Equilibrium elasticities only are estimated due to the lack of dynamics in their specification. The overall cross price elasticity of alcohol with is $+0.50$ suggesting that the two addictive goods are substitutes, while that of cigarettes with respect to the price of alcohol is -0.14. This asymmetry, both in the signs and in the magnitudes, is mainly due to differences in the price responsiveness of the participation decisions[2].

Goel and Morey (1995) use a pooled set of data organized by year and state on US cigarette and liquor consumption for the period 1959-1982. The empirical specification includes habit persistence through lagged consumption of each good in both equations. They find a substitution relationship too, though cross price effects differ markedly: from $+0.33$ for liquor to $+0.10$ for cigarettes. This may be considered as potential evidence of differences in social norms regarding smoking and drinking. Namely, there may be some asymmetry in the number of people who smoke and drink liquor and those who only smoke or only drink liquor. The same idea is put forward in the paper by Picone et al. (2004) where the increases in the costs and barriers to smoking in the US are used to study the relationships between smoking and drinking behaviors. Starting from the observation that smokers consume twice the amount

[1] The Italian Health Institute (Istituto Superiore di Sanità) reports that, over the last years, the number of people treated for multiple addictions (polysubstance use) has steadily increased. See http://www.iss.it/ossfad/ for further details.

[2] Decker and Schwartz distinguish between consumption and participation for both goods. The overall cross price elasticity of alcohol, for instance, with respect to cigarettes is obtained by adding two components: the cross price elasticity calculated from the demand for alcohol over all individuals (both drinkers and non drinkers) and the cross price elasticity calculated from the demand for alcohol among drinkers only. In the case of alcohol these two components have the same sign and add up to +0.50. In the case of cigarettes, instead, the -0.19 cross price elasticity of smoking participation contrasts with the +0.04 cross price elasticity among smokers only, adding up to an overall elasticity of -0.14.

of alcohol per capita as non smokers do and that as many as 80% of alcoholics smoke, they try to investigate the relationship between smoking and drinking using the first six waves of the Health and Retirement Survey (HRS). They also test whether past cigarettes and alcohol consumption affect current alcohol consumption as predicted by co-addiction models. Their main findings can be summarised as follows: past consumption of cigarettes has a positive effect on current alcohol consumption; increasing the cost of smoking (through the introduction of smoking bans) reduces alcohol consumption; finally, higher cigarette prices increase alcohol consumption.

Jones (1989) estimates budget shares equations using an Almost Ideal Demand System (AIDS) which includes four categories of alcoholic beverages and tobacco, using aggregate quarterly expenditure data for the UK over the period 1964-1983. He finds tobacco to be a complement to all four categories of alcoholics. Habit formation is depicted in the model by lagged consumption for each commodity.

A similar study has been carried out by Fanelli and Mazzocchi (2004) who, in addition, develop a dynamic modeling approach to the AIDS, which is consistent with the rational addiction theory and with the hypothesis of adjustment costs. A strong complementarity between alcohol and tobacco consumption is found in the data. Jimenez and Labeaga (1994) estimate static demand equations in a demand system context because of lack of time variability in the data: a cross section of individual expenditures taken from the Spanish Family Expenditure Survey (SFES). The resulting cross price elasticity of tobacco consumption with respect to alcohol price is, on average, -0.78 suggesting a rather strong complementarity between the two commodities.

Dee (1999) provides evidence for a robust complementarity between drinking and smoking among teen agers using pooled cross sections from the 1977-1992 Monitoring the Future (MTF) surveys of high school seniors. They evaluate such complementarity by exploiting the exogenous variation in the full prices of alcohol and tobacco generated by changes in cigarette taxes and state minimum legal drinking ages. Contemporaneous complementarity or substitution is evaluated through the estimated coefficients of the price of alcohol in the cigarette equation and of the price of cigarettes in the alcohol equation, whereas no elasticities are calculated.

Finally, Bask and Melkersson (2004) model the demand for alcohol and cigarettes as two separate equations and then as a simultaneous system. The dependence of current consumption from past consumption is modeled assuming a non common habit stock, i.e. consumption is only a function of its own stock of past consumption and not of the joint stock of both goods. They use aggregate annual time series on sales volumes for the period 1955-1999 in

Sweden. Both cross price elasticities turn out to be negative thus showing that alcohol and cigarettes are complements in consumption. Some of their findings are, however, problematic. The coefficients on lead and lagged tobacco consumption, in the tobacco equation, are always negative thus contradicting the theory. Secondly, standard errors for the elasticites are never reported and there is no comment on the values of the calculated cross price elasticities. Finally, looking at equations 7 and 8 one forms the opinion that there is only one discount rate. Table 6, however, presents two sets of implied rates, though the figures referring to equation 8 are not calculated, because rational addiction is not present.

Table 1 summarizes results from previous studies on cigarettes and alcohol. In the table, $\varepsilon_{a,t}$ is the cross price elasticity of alcohol with respect to tobacco and $\varepsilon_{t,a}$ is the cross price elasticity of tobacco with respect to alcohol. They measure the percentage change in the quantity demanded of one addictive good following a 1% change in the price of the other.

3 Modeling the Stock of Alcohol and Tobacco Consumption

A growing body of medical evidence shows that alcohol and tobacco consumption are related (Decker and Schwartz, 2000, p. 4), due to a range of biological and psychological factors. Walton (1972) for instance, found that 97% of a sample of male alcoholics were smokers. Bobo et al. (1987) reported that 92.3% of the staff interviewed in an alcohol treatment facility estimated that 75 to 100% of their patients smoked. In general, it has been observed that individuals who declare currently using alcohol, very often report current use of tobacco as well. Recently, Picone et al. (2004) stressed that the hypothesis according to which smoking and drinking behaviours are positively correlated is supported by a large epidemiological literature.

These stilized facts seem consistent with the conjecture that smoking and drinking reflect a "common addictive personality pattern". An explanation for it is the so called "learning based explanation": smoking and drinking may serve as mutual cues in the sense that the use of one substance stimulates the consumption of the other. This may be due to situational factors: sitting in a bar having a drink may trigger smoking; or to pharmacological factors: the use of alcohol reinforces the effect of nicotine and vice versa. While their contemporaneous relationship has been explored in the literature using different modeling approaches, the inter temporal relationship between alcohol and tobacco consumption, i.e. the hypothesis that their combined usage may also depend on past consumption of both, has yet to be taken into account. This is, however, quite important, because a positive effect of past consumption of one substance on current use of the other is necessary in order to have a so called "Gateway Effect": i.e. past consumption of a legal addictive substance may reinforce the current use of an illicit addictive drug. Pacula (1997) reports that defining a common capital stock is crucial (p. 522) since a Gateway Effect occurs when past consumption of one substance increases the marginal utility of the other, thus inducing the individual to actually consume the latter substance[3]. Her analysis is generalisable to consider two legal and harmful substances such as alcohol and tobacco, but she does not explicitly introduce any functional specification for the common stock.

The empirical literature on the interaction between alcohol and tobacco consumption has modeled the joint habit stock in two different ways. A common habit stock is assumed when the following linear specification holds (Bask-Melkersson, 2003) : $H(t) = c(t-1) + s(t-1)$ (where c is cigarettes and s is snus, a particular kind of smokeless tobacco). This formulation of the habit stock implies that past consumption of any of the two goods gives rise to a single stock accumulation. The two goods are perfect substitute, i.e. they show an infinite elasticity of substitution. We do not know of specifications of the common habit stock other than the linear additive one used by Bask and Melkersson. This specification, however, is not reasonable when applied to alcohol and tobacco. A more general formulation is to assume that past consumption of both goods leads to the accumulation of two separate habit stocks. Assuming that each habit stock is equal to its own past consumption gives (Bask and Melkersson, 2003): $S_t = A_{t-1}$; $H_t = T_{t-1}$, where A_t is alcohol and T_t is tobacco. The justification for two separate habit stocks is that there are different social, psychological and physiological factors connected with each addictive good and one cannot freely substitute one addiction source for another.

[3] A true Gateway Effect occurs when consumption of one substance increases the subsequent likelihood of initiation of other substances by increasing their marginal utility of consumption. Let us consider alcohol and tobacco and suppose we want to test whether tobacco is a gate to alcohol. An individual will initiate consumption of alcohol, if its marginal utility, evaluated at zero consumption, is greater than its marginal cost, i.e. its price. What makes, at zero consumption, the marginal utility of alcohol greater than its price, is the existence of habit formation with respect to the gate good, i.e. past consumption of tobacco (see Pacula, 1997, p. 522).

4 Theoretical Framework

In the RA framework (Becker and Murphy, 1988) the behaviour of an addicted consumer is characterized by reinforcement and tolerance. Tolerance means that the marginal utility of the stock of past consumption is negative; reinforcement, on the other hand, requires that an increase in past consumption raises the marginal utility of current consumption. An implication of reinforcement is that levels of consumption in adjacent time periods are complements. In addition, the RA framework implies that consumers also take into account the future negative consequences of their behavior so that, for reinforcement to occur, the increase in the marginal utility of current consumption following an increase in past consumption must be greater than the reduction in the present value of future consumption due to the harmful consequences of addiction. Underlying the RA theory are several assumptions that have led to a bulk of critical literature and have given rise to new classes of addiction models. In particular: i) initiation in consumption is not explained: the individual consumes positive amounts of the addictive good; ii) s/he can accurately predict future prices and other demand shifters; iii) s/he is not only rational and forward looking, but also time consistent (O'Donoghue-Rabin, 1999; Gruber-Köszegi, 2001); s/he does not have self control problems (Akerlof, 1991; Elster and Skog, 1999); the model fails to explain important aspects of addictive behaviour, such as temptation (Gul-Pesendorfer, 2005); mistaken behaviour (Lowenstein-O'Donoghue-Rabin, 2003); cue-triggered decision processes (Bernheim-Rangel, 2005).

Nevertheless, the model is still very popular among practitioners, because it leads to a simple linear specification with testable hypothesis.

Following Andersson et al. (2003) and Bask and Melkersson (2004), given two addictive goods consumed, such as Alcohol, A, and Tobacco, T, the habit stock variable is:

$$
\begin{aligned}
S_t &= A_{t-1} + \delta T_{t-1} \\
H_t &= (1-\delta) T_{t-1}
\end{aligned} \tag{1}
$$

where $0 \leq \delta \leq 1$. When $\delta = 0$ we have a non common habit stock, i.e. past consumption of each good leads to the accumulation of two different stocks. $\delta = 1$ is instead the case of a joint habit stock.

The representative consumer's problem is to maximize the following function:

$$
V = \max \sum_{t=1}^{T} \beta^{t-1} U \left(C_t, A_t, T_t, S_t, H_t \right) \tag{2}
$$

where C_t is consumption at time t of a non addictive good (used as numeraire), A_t is consumption of alcohol at time t, T_t is consumption of tobacco at time t, and S_t and H_t are the habit stock variables, whereas β is the discount factor $1/(1+r)$, with r being the inter temporal rate of time preference. The utility function has the following properties: $U_A < 0$; $U_{AA} < 0$; $U_T < 0$; $U_{TT} < 0$; $U_C < 0$; $U_{CC} < 0$. Moreover, the standard properties of addiction: tolerance and reinforcement are assumed to hold: $U_H < 0$; $U_{HH} < 0$; $U_S < 0$; $U_{SS} < 0$; $U_{AS} > 0$; $U_{TH} > 0$. Drinking and smoking are assumed to have no effect on the marginal utility derived from consuming the composite good C and vice versa: $U_{AC} = U_{TC} = U_{SC} = U_{HC} = 0$. Finally, if the consumption of one good lessens the quitting of the other, a necessary condition is that smoking affects the marginal utility derived from the other good negatively, i.e. $U_{TA} < 0$ and $U_{HS} < 0$. On the other hand, if smoking reinforces the craving for alcohol and viceversa, the necessary condition is $U_{TA} > 0$ and $U_{HS} > 0$. Thus, a necessary condition for tobacco to be a gate to alcohol is $U_{HS} > 0$ and for alcohol to be a gate to tobacco is $U_{SH} > 0$. The inter temporal budget constraint for the representative consumer is:

$$\sum_{t=1}^{T} \beta^{t-1} \left(Y_t + p_{A_t} A_t + p_{T_t} T_t\right) = W \tag{3}$$

where W is the present value of wealth.

When the instantaneous utility function is quadratic and the inter temporal rate of time preference is equal to the market interest rate solving equation (2) generates the following structural demand equations:

$$A_t = \beta_{10} + \beta_{11} A_{t-1} + \beta_{12} A_{t+1} + \beta_{13} T_{t-1} + \beta_{14} T_t + \beta_{15} T_{t+1} + \beta_{16} p_{A_t} \tag{4}$$

$$T_t = \beta_{20} + \beta_{21} T_{t-1} + \beta_{22} T_{t+1} + \beta_{23} A_{t-1} + \beta_{24} A_t + \beta_{25} A_{t+1} + \beta_{26} p_{T_t} \tag{5}$$

Where $\beta_{i0} > 0$, $\beta_{i1} > 0$, $\beta_{i2} > 0$, $\beta_{i6} < 0$ and $\beta_{i1} = (1+r)\beta_{i2}$with $i = 1, 2$; that is: current consumption is positively related to past and future consumption and negatively related to own current price. Testing these parameter restrictions has in the literature been used as a validation of the rational addiction model. The signs of the remaining parameters depend on data, i.e. on how the consumption of the two goods affects each other. One of the impications of the coaddiction model and the Gateway Effect is that past levels of cigarette consumption should reinforce current consumption of alcohol and conversely $\beta_{i3} > 0$ $(i = 1, 2)$. When a linear common habit stock is assumed $(\delta = 0)$, there is an addictional parameter restriction imposed on both equations: $\beta_{i1} = \beta_{i3}$ $i = 1, 2$, i.e. lagged consumption of tobacco has the same effect as lagged consumption of alcohol, regardless of the equation.

Combination of equations (4) and (5) leads to the following semi-reduced system:

$$A_t = \alpha_{10} + \alpha_{11}A_{t-1} + \alpha_{12}A_{t+1} + \alpha_{13}T_{t-1} + \alpha_{14}T_{t+1} + \alpha_{15}p_{A_t} + \alpha_{16}p_{T_t} \quad (6)$$

$$T_t = \alpha_{20} + \alpha_{21}T_{t-1} + \alpha_{22}T_{t+1} + \alpha_{23}A_{t-1} + \alpha_{24}A_{t+1} + \alpha_{25}p_{T_t} + \alpha_{26}p_{A_t} \quad (7)$$

Where the $\alpha's$ are non linear combinations of the $\beta's$ and their expected signs cannot be deduced from the theory[4].

For policy purposes, the long run direct and cross price elasticities of demand are of interest, because they measure the response between steady states, to a permanent change in price. For the semi-reduced system these elasticities, calculated at the sample mean, are given by:

$$\varepsilon_{AA} = \frac{dA}{dp_A}\frac{\overline{p_A}}{\overline{A}} = \frac{(1-\alpha_{21}-\alpha_{22})\alpha_{15} + (\alpha_{13}+\alpha_{14})\alpha_{26}}{(1-\alpha_{11}-\alpha_{12})(1-\alpha_{21}-\alpha_{22}) - (\alpha_{13}+\alpha_{14})(\alpha_{23}+\alpha_{24})}\frac{\overline{p_A}}{\overline{A}} \quad (8)$$

$$\varepsilon_{AT} = \frac{dA}{dp_T}\frac{\overline{p_T}}{\overline{A}} = \frac{(1-\alpha_{21}-\alpha_{22})\alpha_{16} + (\alpha_{13}+\alpha_{14})\alpha_{25}}{(1-\alpha_{11}-\alpha_{12})(1-\alpha_{21}-\alpha_{22}) - (\alpha_{13}+\alpha_{14})(\alpha_{23}+\alpha_{24})}\frac{\overline{p_T}}{\overline{A}} \quad (9)$$

$$\varepsilon_{TT} = \frac{dT}{dp_T}\frac{\overline{p_T}}{\overline{T}} = \frac{(1-\alpha_{11}-\alpha_{12})\alpha_{25} + (\alpha_{23}+\alpha_{24})\alpha_{16}}{(1-\alpha_{11}-\alpha_{12})(1-\alpha_{21}-\alpha_{22}) - (\alpha_{13}+\alpha_{14})(\alpha_{23}+\alpha_{24})}\frac{\overline{p_T}}{\overline{T}} \quad (10)$$

$$\varepsilon_{TA} = \frac{dT}{dp_A}\frac{\overline{p_A}}{\overline{T}} = \frac{(1-\alpha_{11}-\alpha_{12})\alpha_{26} + (\alpha_{23}+\alpha_{24})\alpha_{15}}{(1-\alpha_{11}-\alpha_{12})(1-\alpha_{21}-\alpha_{22}) - (\alpha_{13}+\alpha_{14})(\alpha_{23}+\alpha_{24})}\frac{\overline{p_A}}{\overline{T}}$$

If, in the statistical model, we add a proxy of disposable income, Y_t , to the set of explanatory variables we can also estimate the expenditure elasticities of demand[5]:

$$\varepsilon_{AY} = \frac{dA}{dY}\frac{\overline{Y}}{\overline{A}} = \frac{(1-\alpha_{21}-\alpha_{22})\alpha_{17} + (\alpha_{13}+\alpha_{15})\alpha_{27}}{(1-\alpha_{11}-\alpha_{12})(1-\alpha_{21}-\alpha_{22}) - (\alpha_{13}+\alpha_{15})(\alpha_{23}+\alpha_{25})}\frac{\overline{Y}}{\overline{A}} \quad (11)$$

$$\varepsilon_{TY} = \frac{dT}{dY}\frac{\overline{Y}}{\overline{T}} = \frac{(1-\alpha_{11}-\alpha_{12})\alpha_{27} + (\alpha_{23}+\alpha_{25})\alpha_{17}}{(1-\alpha_{11}-\alpha_{12})(1-\alpha_{21}-\alpha_{22}) - (\alpha_{13}+\alpha_{15})(\alpha_{23}+\alpha_{25})}\frac{\overline{Y}}{\overline{T}}$$

In the case of one addictive good, the inter temporal rate of time preference, r, can be easily derived from the structural parameters. In the semi-reduced system, however, the parameters

[4]See Bask and Melkersson (2003) for explicit expressions for these parameters.

[5]$\alpha_{i7}(i = 1, 2)$ is the semi-reduced parameter of expenditure (Y) when this variable is included among the regressors.

of each equation are non linear functions of the parameters in equations (4) and (5) and their expected sings cannot be deduced from the theory. Therefore the well known formula to calculate the inter temporal rate of time preference, out of parameters of the RA structural demand equation, does not apply in this case. Results from the semi-reduced system cannot be interpreted in the sense of accepting or rejecting the theoretical assumptions implied by the RA model. However, the coefficients of the semi-reduced system can be used to calculate own, cross price and income elasticities; to test for the existence of a gateway effect and to draw important policy implications.

5 Data and Empirical Strategy

5.1 Alcohol and Tobacco Consumption in Italy

In the year 2000 average per capita consumption of pure alcohol in Italy was about 7.5 litres (Ministero della Salute, 2003, p. 12), but according to the WHO for the European Region, the target of 6 litres per capita per year should be reached by the year 2015. Alcohol consumption has followed a decreasing trend since the early eighties: per capita consumption of an aggregate of beer, wine and spirits has decreased, between 1970 and 2001, by 51.25%.

The Italian Institute of Health (Scafato and Russo, 2004, p. 4), reports that the total per capita decrease in alcohol consumption from 1981 to 2000 results from a 40.8% decrease in wine consumption; a 65.7 % decrease in spirits consumption and a 57% increase in beer consumption.

At the same time, however, the following changes have occurred: a) an increase in the number of female consumers; b) an increase in the number of young consumers (teen agers and people aged 18 to 24); c) an increase in the number of people (and the increase is higher for females and the young) consuming alcohol outside the main meals. The increase in the number of alcohol consumers on one hand and the sharp decrease in per capita level of consumption, on the other, seem to reveal a change in habits. Italy is a producer country where, traditionally, wine has been consumed, on average, in moderate quantities and by all members of the household, to accompany meals. This pattern seems to suggest a transition from a Mediterranean model to one closer to the Northern European countries characterised by binge drinking and by the use of alcohol as a bridge to ease personal relationships and wane down social discomfort or as a means of female emancipation and cultural homologation. If this is true, then the steady decrease in alcohol consumption could hide a rather different picture such as an increase in the number of people actually at risk, especially among the most fragile groups of society.

As to smoking behaviour, Italy is one of the industrialised countries with a very high percentage of daily smokers (OECD, 2002). The Italian National Statistical Office (ISTAT, 2002b) estimates that in the year 2000 smokers in Italy were 12.330.000, about 24.9% of the population older than 14. Among those, 22.9% were abitual smokers (those that smoke every day) and 40.9% heavy smokers (those declaring to smoke more than 20 cigarettes per day). Smoking in Italy is highly influenced by sex, age, location and the level of education attained. There are more male smokers than females (32% of males smoke against about 18% of females) and the highest share of smokers is registered in North-West and Central Italy (26.2%), followed by the Islands (24.5%), the South (23.8%) and the North-East (23.5%).

Households' expenditure on tobacco, at constant 1995 prices, has grown between 1982 and 1986 and has decreased steadily between 1987 and 1995 (ISTAT, 2002a). Since then expenditure on tobacco has almost remained stable. However, this decrease is likely to be due, at least partly, to the rapid increase in cigarette smuggling, estimated to have grown by about 800% between 1985 and 1993 and to account for about 13% of all cigarettes consumed.

5.2 Data

We use aggregate time series of alcoholic beverages' and tobacco products' expenditures (both in Billions Euro) in Italy for the period 1960-2002 taken from ISTAT National Accounts. The use of aggregate data implies a number of drawbacks: first, they may be dominated by the behavior of light and moderate drinkers or smokers and a decrease in aggregate consumption of alcohol, for instance, could hide a rather different trend in consumption of each alcoholic beverage (beer, wine and spirits). Secondly, addictive behavior could be more easily captured by data on spirits consumption and on cigarettes consumption only, because the distribution of spirits and cigarettes is tipically more bimodal than that of other alcoholics or tobacco products[6]. Finally, Auld and Grootendorst (2004) have argued that estimable RA models tend to yield spurious evidence in favor of the RA hypothesis when aggregate time series are used. More specifically, spurious evidence in favour of RA is likely to be obtained when: 1) the consumption series is highly correlated; 2) even a small amount of the variation in prices is endogenous; 3) the value of the discount rate is exogenously imposed and, 4), over identified

[6]Bimodal distribution is an outcome of the Becker-Murphy theory of addiction and it implies that there are few consumers of small or moderate quantities of addictive goods and a majority either not consuming at all or consuming large quantities of the highly addictive good.

instrumental variable estimators are used.

Per capita values are obtained by dividing aggregate expenditures of both commodities by population older than 14 (calculated in the middle of each year)[7]. The real price of alcoholics and tobacco is obtained by dividing the implicit deflator, calculated as the ratio between current expenditure and expenditure at 1995 prices, by the consumer price index (1995=1). Summary statistics and details of the data used are presented in table 2. Figure 1 shows an index (1995=1) of per capita expenditures and their real prices normalized in 1995.

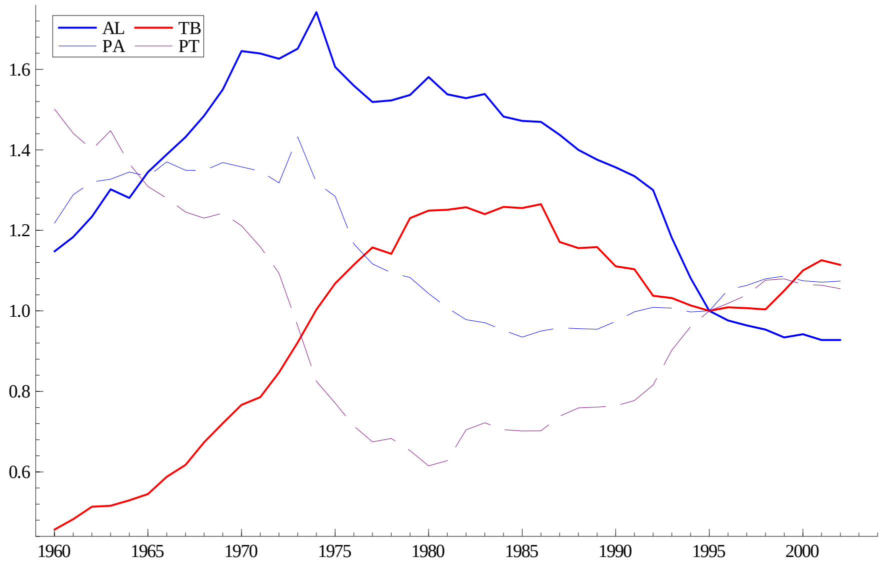

Figure 1: Index (1995=1) of per capita (age >14) alcohol expenditure (AL), per capita tobacco expenditure (TB), real alcohol price (PA) and real tobacco price (PT).

5.3 Diagnostic Tests on Time Series

A number of diagnostic tests have been performed in order to avoid biases towards finding rational addiction, as suggested by Auld and Grootendorst (2004). First we have tested for price exogeneity performing a Hausman-Wu (HW) test[8]. This is a Likelihood Ratio (LR) test

[7]We also have carried out estimations on data in aggregate levels (without dividing by the population) and on per capita levels that take into account the total population.

[8]The HW test compares the original demand equation (estimated with OLS) with the unrestricted model that includes, among the explanatory variables, the residuals of an auxiliary regression. In the auxiliary

distributed as a χ^2 with 34 degrees of freedom. Both for alcohol and for tobacco we accept the null hypothesis of price and disposable income exogeneity.

We have also checked for stationarity of the series using an Augmented Dickey-Fuller (ADF) test. First we have assumed that the data generating process (DGP) is AR(1) with a constant added (random walk with drift) and we have considered the following as a DGP for all the series: $\Delta z_t = az_{t-1} + b_1\Delta z_{t-1} + b_p\Delta z_{t-p} + c + u_t$ where z is the variable under consideration, u_t is white noise, c is the intercept and $t = p + 2, ..., n$. The null hypothesis is that z_t is a unit root process, i.e. $a = 0$ and the test statistic is the t-value of a.

The problem with the ADF is that it is an asymptotic test that may be biased when applied to small samples. For this reason we have also simulated the actual p-value of the ADF test using bootstrapping: the errors have been drawn from a normal distribution with zero mean, variance equal to the squared OLS residuals and a p-value has been calculated based on 500 simulations. Both tests reveal the presence of a unit root for all the variables but P_T[9]. Results of unit root tests are shown in table 3[10]. All estimations have been therefore carried out with the model in first differences. Finally we have tested for autocorrelation of the differenced variables using two different tests: a Durbin'h alternative and a Breusch/Godfrey LM test. For all autocorrelation tests we reject the null of no autocorrelation[11] and accept the hypothesis of serial correlation of order 2 in the error terms of the differenced model. Results of these diagnostic tests are shown in table 3.

5.4 Estimating the rational co-addiction model

Without loss of generality, we sketch estimation of equation (4). The same methods are used to estimate the other behavioural equation (5). A suitable transformation to eliminate the problems of spurious regression, is the following transformation in first-differences:

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regression the real price is the dependent variable whereas the explanatory variables include a linear time trend, a constant and the aggregate quantity of Alcoholic beverages or of Tobacco sold.

[9] P_T is a stationary series when the ADF is applied. However a Phillips-Perron test carried out on the same series accepts the null of a unit root in the DGP.

[10] Unit root tests have been performed using the EasyReg software by prof. Bierens.

[11] The Durbin's h alternative follows a normal distribution and it is a valid test for autocorrelation when more than one lagged dependent variable is included in the regressors.

The Breusch-Godfrey LM test for autocorrelation of order x follows a χ^2 distribution with $DF = x + k - 1$, where x is the number of lags and k is the number of identified coefficients in the model, including the intercept.

$$\Delta A_t = \beta_{10} + \beta_{11}\Delta A_{t-1} + \beta_{12}\Delta A_{t+1} + \beta_{13}\Delta T_{t-1} + \beta_{14}\Delta T_t + \beta_{15}\Delta T_{t+1} + \beta_{16}\Delta p_{A_t} + \beta_{17}\Delta Y_t + \Delta\varepsilon_t \tag{4a}$$

where $t = 3, ..., T-1$; ε_t is the error term; and Y_t, which is an empirical modification of the theoretical model, is a vector of exogenous determinants that influence alcohol and tobacco consumption. In our case, the vector Y_t contains only one element, namely, the real per capita expenditure used as a proxy of disposable income.

There are two problems that prevent the linear expression (4a) from being estimated by ordinary least squares. First, there is an omitted variable bias due to uncounted demand shifters that may also be serially correlated. Second, there is measurement error when we use actual values in period $t+1$ for planned future consumptions of both addictive goods (Picone, 2005).

The common strategy when facing such endogeneity problems is to assume that there exists a vector of instruments, which may include one or all of covariates, and apply the generalized method of moments (GMM)[12]. The $lx1$vector of instruments, Z_t, say, is uncorrelated with the disturbance and correlated with the explanatory variables and satisfies the set of l orthogonality conditions $E\left(Z_t\Delta\varepsilon_t\right) = 0$. The sample analogue of these moment conditions is given by the column vector $n^{-1}\sum_{t=1}^{n} Z_t\Delta\varepsilon = 0$ or, dropping the factor n^{-1} and using matrix notation, $Z'\Delta\varepsilon = 0$. If the model is overidentified, i.e. the number of independent moment conditions is greater than the number of estimated parameters ($l > k$), the GMM estimator of the linear equation (4a) is obtained by minimizing a quadratic form in the sample moments and is given by:

$$\widehat{\beta}_{GMM} = \left[\left(\sum_{t=1}^{n} X_t Z_t'\right)\omega^{-1}\left(\sum_{t=1}^{n} Z_t X_t'\right)^{-1}\right]\left[\left(\sum_{t=1}^{n} X_t Z_t'\right)\omega^{-1}\left(\sum_{t=1}^{n} Z_t Y_t\right)\right] \tag{4b}$$

or in matrix notation

$$\widehat{\beta}_{GMM} = \left(X'Z\omega^{-1}Z'X\right)^{-1} X'Z\omega^{-1}Z'Y \tag{4c}$$

where,$X = [1, \Delta A_{-1}, \Delta A_{+1}, \Delta T_{-1}, \Delta T, \Delta T_{+1}, \Delta p_A, \Delta Y]$, $Z\,(nxl)$ is an instrument matrix to be defined, and $\omega\,(lxl)$ is a weighting matrix. Note that while the GMM estimator depends

[12] For a comprehensive discussion on generalized method of moments see Davidson and MacKinnon (1993, chapter 17), Hall (2005), Hansen (2005, chapter 5), Hayashi (2000, chapter 3), and Matyàs (2003), to cite a few.

on ω, the dependence is only up to a scalar. An optimal weighting matrix, i.e., one which minimizes the asymptotic variance of the estimator, is not known in practice, but can be estimated consistently. Since the optimal weighting matrix is a function of β, we need a two-step procedure. In the first step, we use the fact that a consistent yet not efficient estimate of the parameters' vector may be obtained with an arbitrary positive definite and symmetric weighting matrix which does not depend on β. For example, we can set $\widehat{\omega}_1 = I_l$, or $\widehat{\omega}_1 = n^{-1}Z'Z$. Observe that, in the linear model the latter choice implies that the first step estimator is the two stage least squares estimator, originally proposed by Theil (1953). In the second step, any such preliminary estimate of β is used to form $\widehat{\omega} = n^{-1}Z'\Delta\widehat{\varepsilon}\Delta\widehat{\varepsilon}'Z$ where $\Delta\widehat{\varepsilon}$ is a consistent estimate of the disturbance and obtain $\widehat{\beta}_{GMM}$.

After some experimentation, we have chosen as instruments a set that is a combination of past and future prices and expenditure both in levels and in differences: Δp_{A_t}, $\Delta p_{A_{t-2}}$, $\Delta p_{A_{t-3}}$, $p_{A_{t-1}}, p_{A_{t-2}}$, $p_{A_{t+1}}$, $p_{A_{t+2}}$, Δp_{T_t}, $\Delta p_{T_{t-2}}$, $\Delta p_{T_{t-3}}$, $p_{T_{t+1}}$, $p_{T_{t+2}}, p_{T_{t-1}}, p_{T_{t-2}}$, ΔY_t, ΔY_{t-2}, ΔY_{t-3}, Y_{t-1}, Y_{t-2}, Y_{t+1}, Y_{t+2} and the constant.

6 Results

We have carried out different sets of estimations. First, the model in equations (4) and (5) is estimated as two separate structural equations with all the variables in first differences. Past and future consumption of both goods are treated as endogenous in each equation so we use the Generalized Method of Moments (GMM) estimator which produces consistent and asymptotically efficient estimates of the parameters of interest. As Auld and Grootendorst (2004, p. 17) have noted, estimating the model in differences is likely to yield better small-sample properties than estimation in levels for commodities exhibiting moderate to high serial correlation in consumption. The validity of the over identifying restrictions is tested using the Sargan or J test. Standard errors are computed from an heteroscedastic-consistent covariance matrix of the orthogonality conditions using the White procedure. We also control for serial correlation of the disturbances using a covariance matrix of the orthogonality conditions that incorporates Moving Average (MA) disturbances of order 2. The results are shown in table 4. In the alcohol equation current alcohol consumption is positively affected by lagged and lead consumption. The lead consumption coefficient is also lower than the lagged one as expected so that the rate of inter temporal preferences is positive. Alcohol demand is also negatively affected by its own price and by current tobacco consumption. The coefficients of lagged and lead consumption in the tobacco equation are positive and significant, but this time the rate of time preference is negative because the lead consumption coefficient is larger than the lagged consumption one. Also current tobacco demand is negatively affected by current and future alcohol consumption. Finally, alcohol seems to be a gate to tobacco because lagged alcohol consumption is positive and significant in this case. The long run demand elasticities are all negative (see table 5), but tobacco consumption is more sensitive to own price variations than alcohol. The cross price elasticity of alcohol with respect to tobacco is negative, thus signalling complementarity, whereas the other cross price elasticity is very close to zero, but also scarcely significant. Finally, the expenditure elasticity of alcohol is > 1 and has been growing over the whole sample period 1960-2002, showing that alcohol is a luxury.

A second set of results refers to the simultaneous estimation of the semi-reduced system. Our empirical implementation is based on a variant of (6) and (7), with all the variables in first differences as follows:

$$\Delta A_t = \alpha_{10} + \alpha_{11}\Delta A_{t-1} + \alpha_{12}\Delta A_{t+1} + \alpha_{13}\Delta T_{t-1} + \alpha_{14}\Delta T_{t+1} + \alpha_{15}\Delta p_{A_t} + \alpha_{16}\Delta p_{T_t} + \alpha_{17}\Delta Y_t \quad (12)$$

$$\Delta T_t = \alpha_{20} + \alpha_{21}\Delta T_{t-1} + \alpha_{22}\Delta T_{t+1} + \alpha_{23}\Delta A_{t-1} + \alpha_{24}\Delta A_{t+1} + \alpha_{25}\Delta p_{T_t} + \alpha_{26}\Delta p_{A_t} + \alpha_{27}\Delta Y_t \quad (13)$$

where α_{i0}, $i = 1, 2$, is an intercept term and Y_i is real per capita final consumption expenditure used as a proxy of disposable income. If the model is correctly specified one should have $\alpha_{10} = \alpha_{20} = 0$. However, we allow for a non-zero intercept in all estimations in order to avoid mis specification bias in the other parameters. The set of instruments used is the same as in the previous estimations. These results are shown in table 6. Concerning alcohol, the lag and lead consumption are statistically significant, have the expected sign and the lead coefficient is lower than the lagged one, so that the inter temporal rate of time preference is positive. Alcohol price is also statistically significant, as well as disposable income and future tobacco consumption. However, as before, lagged tobacco consumption is negative and is not statistically significant. As to the tobacco equation, all the coefficients, except for lagged alcohol consumption and disposable income, are statistically significant and take on the expected sign. In this case, however, a positive coefficient for the lead consumption of each good in each equation is just evidence that consumers are forward looking and not that the RA theory is supported by the data. This is because, as stated previously, the signs of the parameters in the semi-reduced system cannot be deduced from the theory. Even in this case there is no evidence of a gateway effect in either direction. The test of over identifying restrictions is distributed as a χ^2 with degrees of freedom equal to the number of exceeding instruments. The critical value of the χ^2 at the 95% level of significance with 22 degrees of freedom is 12.391 [p-value 0.949], we cannot therefore reject the null of no over identification.

Direct and cross price long run elasticities of demand calculated at the sample mean, as well as the income elasticities of demand are shown in table 7. Standard errors have been computed using the delta method. Own and cross price elasticities indicate that the coefficients are accurately estimated and in line with those calculated in similar studies. As to direct price elasticities all responses are smaller than unity, but alcohol appears to be less sensitive to price variations than tobacco. The same holds for cross price elasticities of demand. This contrasts with previous findings where the cross price elasticity of alcohol with respect to tobacco price is greater, in absolute value, than the cross price elasticity of tobacco with respect to alcohol. Both elasticities are negative implying that the two goods are complement, but they are asymmetric in magnitude. Goel and Morey (1995, p. 456), who found a similar result, view this as potential evidence of differences in social norms regarding smoking and drinking, i.e. it may be that the intersection of smokers and liquor drinkers constitutes a much larger proportion in the population of alcohol consumers than it does in the population of smokers.

The statistical significance of cross price effects bears important implications for taxation and health policies. In this case, for example, measures aimed at reducing alcohol consumption might produce the additional effect of reducing tobacco consumption as well. Moreover alcohol is a luxury good as the income elasticity of demand is 1.81. Figures 2 to 5 show the time series, 1960-2002, of own, cross price and income elasticities. Tobacco has always been more price sensitive, throughout the period and is also more sensitive to variations in the price of alcohol (figure 3). This finding suggests that increases in the price of alcohol would be effective also in reducing tobacco consumption. It also seems consistent with the intuition by Goel and Morey (1995) who stress a presumed asymmetry in the proportion of people who drink and also smoke: drinkers seem to get more easily hooked in smoking behaviour than smokers do in drinking behaviour. Lastly, from figure 4, we may see how the income elasticity of alcohol consumption has been growing over time and has always been greater than one, i.e. alcoholic beverages are luxuries throughout the period. If the income elasticity of alcohol consumption is also growing across income classes, then alcohol taxation would have a progressive impact, contrary to the conventional wisdom that taxation of "sin" goods is regressive, and would thus be more equitable than tobacco taxation even from a distributional view point.

A final set of results refers to the estimation of the structural demand equations with the additional restriction of a linear common stock. Pacula (1998, p. 9) stresses that in order to test for a gateway effect one should have a single stock representing the cumulative influence of past consumption of both substances. When a linear common habit stock is assumed, the following structural demand equations can be derived from the RA theory:

$$A_t = \beta_{10} + \beta_{11}(A_{t-1} + T_{t-1}) + \beta_{12}A_{t+1} + \beta_{13}T_t + \beta_{14}T_{t+1} + \beta_{15}p_{A_t} \quad (14)$$

$$T_t = \beta_{20} + \beta_{21}(T_{t-1} + A_{t-1}) + \beta_{22}T_{t+1} + \beta_{23}A_t + \beta_{24}A_{t+1} + \beta_{25}p_{T_t} \quad (15)$$

In this model, past consumption of alcohol and tobacco have the same impact on current demand. Testing whether this restriction holds can be considered a test of the hypothesis of a linear common habit stock. However, specifying the common stock as a linear additive function implies: i) that alcohol and tobacco are perfect substitutes in consumption; ii) that, if the coefficients β_{i1} ($i = 1, 2$) turn out to be positive and statistically signirifcant, there is a symmetric gateway effect between the two goods, i.e. past consumption of alcohol and tobacco has an equal effect on current consumption of each good. Since both implications are unreasonable when the goods involved are alcohol and tobacco, we expect to reject the hypothesis of a linear common habit stock and of a gateway effect of this kind[13].

We have performed a LM test on each of the two equations. The null hypothesis is given by the restricted model and the LM test statistic follows a chi-square distribution with DF equal to the number of restrictions. For the alcohol equation, the LM statistic with 1 DF is 6.202, whereas the χ^2 distribution value at the 95% of significance is 3.83, we thus reject the null. In the tobacco equation the LM statistic is 5.019, therefore we reject the null of a linear common habit stock for alcohol and tobacco, as expected.

6.1 Policy Implications

In order to draw some policy implications, we have used the GMM estimates of equations (12) and (13) to evaluate the effects on consumption of both commodities of a change in Alcohol price only from the year 2003. In our simulation real prices are actual ones up until 2002, but we assume a 3% per year growth rate in the real price of Alcohol during the period 2003-2016. The real price of Tobacco and the proxy of disposable income are instead assumed to grow at a rate equal to their past trend. To simulate equations (12) and (13) beyond the estimation period (i.e. after 2002) we need to know the expected future consumption values for both

[13] Bask and Melkersson (2000) model the common stock as a linear additive function when tobacco and smuggling tobacco are the goods involved. In this case it makes sense to assume perfect substitution between the two goods, because they are the same good, it is only the institutional setting that is different.

Alcohol and Tobacco. These are generated through OLS estimation of the following set of equations from 1963 to 1999, where instruments only are used as explanatory variables:

$$A_t = c_0 + c_1 p_{A_t} + c_2 p_{At-1} + c_3 p_{At-2} + c_4 p_{At+1} + c_5 p_{At+2} + c_6 y_t + c_7 y_{t-1} + c_8 y_{t-2}$$
$$+ c_9 y_{t+1} + c_{10} y_{t+2} + c_{11} p_{Tt-1} + c_{12} p_{Tt-2} + c_{13} p_{Tt+1} + c_{14} p_{Tt+2} + u_{At} \quad (16)$$
$$T_t = d_0 + d_1 p_{T_t} + d_2 p_{Tt-1} + d_3 p_{Tt-2} + d_4 p_{Tt+1} + d_5 p_{Tt+2} + d_6 y_t + d_7 y_{t-1} + d_8 y_{t-2} \quad (17)$$
$$+ d_9 y_{t+1} + d_{10} y_{t+2} + d_{11} p_{At-1} + d_{12} p_{At-2} + d_{13} p_{At+1} + d_{14} p_{At+2} + u_{Tt}$$

Equations (16-17) are estimated for the years 2003 - 2020 using as prices those generated as described above. Given these exogenous information on A_{t+1}, T_{t+1}, p_{At}, p_{Tt} and Y_t , equations (12) and (13) are dynamically simulated from 1962 to 2016. Results of this exercise are shown in figure 5 and table 8. When an increase of 3% per year in Alcohol price is assumed, the consumption of both commodities decreases as a consequence of complementarity between them. Even though the proportional reduction in Tobacco consumption is lower, acting on Alcohol price only seems to be enough to affect both demands.

7 Concluding comments

This paper investigates the inter relationship between alcohol and tobacco consumption. A range of empirical evidence emphasizes that these goods are often jointly consumed, thus it is likely that they are related in consumption. An understanding of their interdependence is important for a number of reasons. It may help designing appropriate policy measures aimed at reducing the negative externalities associated with their consumption. It may reveal whether there is a gateway effect between the two.

We model the demand for the two addictive goods as an extension of the RA model that allows for multi-commodity addictions.

Our results reveal that there is a strong habit persistence effect in both alcohol and tobacco consumption and, also, that both demands reflect a forward looking behaviour since the lead consumption terms, in each equation, are positive and significant. We cannot say, however, from these findings, whether the joint demand for alcohol and tobacco is well portrayed by the rational addiction model.

Our analysis also reveals that the two goods are complements in consumption since both cross price elasticities are negative. Thus, a policy measure that is effective in reducing the demand in one of the two would also produce the additional result of curbing the demand of the other. More specifically, the cross price elasticity of tobacco with respect to alcohol price is greater in absolute value than the response of alcohol consumption to a change in the price of tobacco.

The asymmetry in the values of the cross price elasticities coupled with the relative magnitude of the own price elasticities seems to suggest that the optimal strategy for maximizing public revenues through increases in "sin" excise taxation would be to raise alcohol taxation more than tobacco. This policy measure would also produce the additional dividend of curbing tobacco demand, given the absolute values of the cross price elasticities. Moreover, alcohol turns out to be a luxury across the whole sample 1960-2002 (see figure 4). If the income elasticity of alcohol consumption is also growing across income classes, then, contrary to the conventional wisdom that views taxation of "sin" goods as regressive, alcohol taxation could have a progressive impact. This would make alcohol more suitable than tobacco for increases in excise taxation.

Such conclusions should be taken with some caution. On one hand, the level of aggregation in our data may conceal individual attributes hanving an influence in consumption of alcohol and tobacco. Moreover, we could only partly account for the suggestions of Auld and Grootendorst (2004) when dealing with aggregate time series data in estimating rational addiction models. The use of data at the individual level is likely to produce more reliable results.

Finally, an interesting topic that has not been extensively explored in the literature is the possibility of a common habit stock between alcohol and tobacco products. While some stilized facts seem to suggest that smoking and drinking often go together, thus admitting a contemporary relationship between the two, there are few empirical tests of the hypothesis of an inter temporal relationship, introduced by Pacula (1997). In this case the joint consumption of the two goods may give rise to a common habit stock and to a gateway effect. We have explored the possibility of a linear common stock between alcohol and tobacco which implies perfect substitution between the two. As expected, though, this assumption is rejected by the data. An appropriate specification of the common stock is thus needed to properly test for a gateway effect between alcohol and tobacco consumption.

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Table 1: Empirical Studies on the Interaction between Alcohol and Tobacco

	DATA	MODEL	DYNAMIC SPECIFICATION	CONTEMPORANEOUS INTERACTION	
				$\varepsilon_{a,t}$	$\varepsilon_{t,a}$
Jones (1989)*	Quarterly aggregate time series	AID system	Habit Formation	-0.46	-0.46
Jimenez-Labeaga (1994)	Cross section, individual data	AID system	Static	-	-0.78
Goel-Morey (1995)	Pooled time series and cross-sections	two separate linear equations	Habit Formation	-0.33	+0.10
Dee (1999)	Pooled time series and cross-sections	two separate linear equations	Static	-	-
Decker-Schwartz (2000)	Cross section, individual data	two separate linear equations	Static	+0.50	-0.14
Bask-Melkersson (2004)§	Annual aggregate time series	simultaneous linear equations	Rational Addiction	+0.79	-0.31
Fanelli-Mazzocchi (2004)	Quarterly aggregate time series	Dynamic AIDS	Rational Addiction	-0.50	+0.01
Picone et al. (2004)	Panel, individual data	two separate linear equations	Habit Formation	-	-

* The values of the cross price elasticies are referred to spirits and tobacco. Symmetry is imposed in estimation.

§ The values are referred to the GMM(b) estimation.

Table 2: Definitions, Means (M) and Standard Deviations (SD) of Variables

Variable	Definition, mean (M), Standard Deviation (SD)
$CT_t = (TBQ/N14)100$	Per capita (of persons aged 14 or older) Tobacco expenditure (1995=1); (M=0.968; SD=0.256)
CA_t	Per capita (of persons aged 14 or older) Alcohol expenditure (1995=1); (M=1.351; SD=0.241)
$PT_t = (TBV_t/TBQ_t)/PG_t$	Real price of Tobacco products (1995=1) (M=0.974; SD=0.263)
$PA_t = (ALV_t/ALQ_t)/PG_t$	Real price of Alcoholic beverages (1995=1) (M=1.139; SD=0.161)
TBQ_t	Aggregate expenditure on Tobacco products, at constant 1995 prices (millions Euro); (M=8252.438; SD=2550.896)
TBV_t	Aggregate expenditure on Tobacco products at current prices (millions Euro); (M=4198.528; SD=4176.161)
ALQ_t	Aggregate expenditure in alcoholic beverages, at constant 1995 prices (millions Euro); (M=5417.678; SD=837.055)
ALV_t	Aggregate expenditure on alcoholic beverages at current prices (millions Euro); (M=2577.546; SD=1882.417)
$Y_t = Y95_t/N14$	Real per capita disposable income per year (1995=1) (M=0.783; SD=0.234)
$Y95_t$	Households' final consumption expenditure per year used as a proxy of disposable income (in Billions Lire) (M=29850.430; SD=37495.442
$N14$	Population aged 14 or older calculated in the middle of each year (in Millions units)
PG_t	Consumer price index (CPI) (1995=100) (M=0.481; SD=0.406)

Table 3: Diagnostic Tests on Time Series (p-values in parentheses)

	1. Price exogeneity		2. Unit Root				3. Autocorrelation (differenced model)	
	P_T	P_A	P_T	P_A	C_T	C_A	DC_T	DC_A
1. LR(HW) test	0.203	0.137						
	(1.000)	(1.000)						
2a ADF			-3.473	-0.202	-0.193	-0.647		
			(0.010)	(0.240)	(0.080)	(0.860)		
Bootstrapping			(0.054)	(0.680)	(0.174)	(0.734)		
3a Durbin's h Alt.							-2.251	-2.327
							(0.024)	(0.020)
3b Breusch-Godfrey							5.065	5.416
							(0.024)	(0.020)

Table 4: GMM Estimates of the demand for alcohol and tobacco estimated separately, (standard errors in parentheses)

Alcohol equation		Tobacco equation	
T_t	-0.211 (0.157)	A_t	-0.096 (0.061)
ΔA_{t-1}	0.319 (0.094)	ΔA_{t-1}	0.094 (0.050)
ΔA_{t+1}	0.230 (0.158)	ΔA_{t+1}	-0.026 (0.061)
ΔT_{t-1}	-0.066 (0.149)	ΔT_{t-1}	0.215 (0.082)
ΔT_{t+1}	0.403 (0.192)	ΔT_{t+1}	0.491 (0.102)
Δp_{A_t}	-0.136 (0.056)	Δp_{T_t}	-0.185 (0.082)
ΔY_t	1.333 (0.357)	ΔY_t	0.154 (0.121)
α_A	-0.032 (0.008)	α_T	0
Test of over. restr.	9.411		8.499
p-value	[0.804]		[0.902]
$R^2(adj)$	0.24		0.23
n	37		37

Standard errors are both heteroscedastic consistent and robust to autocorrelation: the disturbance terms are specified as a second order moving average process.

Table 5: Elasticities of demand at the sample mean and discount rates (standard errors in parentheses)

	parameters	P-value
ε_{AA}	-0.248 (0.156)	[0.113]
ε_{AT}	-0.124 (0.166)	[0.457]
ε_{TT}	-0.618 (0.111)	[0.000]
ε_{TA}	0.033 (0.057)	[0.560]
ε_{AY}	1.754 (0.462)	[0.000]
ε_{TY}	0.192 (0.582)	[0.742]
r_A	38.570 (116.135)	[0.740]
r_T	-56.183 (18.804)	[0.003]

Standard errors have been computed using the delta method.

Table 6: GMM Estimates of the semi-reduced system,
non common habit stock (standard errors in parentheses)

	Alcohol equation	Tobacco equation
ΔA_{t-1}	0.266 (0.085)	0.010 (0.051)
ΔA_{t+1}	0.208 (0.122)	0.374 (0.048)
ΔT_{t-1}	-0.189 (0.207)	0.113 (0.087)
ΔT_{t+1}	0.462 (0.175)	0.374 (0.048)
Δp_{A_t}	-0.154 (0.067)	-0.118 (0.034)
Δp_{T_t}	0.019 (0.060)	-0.257 (0.036)
ΔY_t	1.440 (0.407)	0.021 (0.215)
α_{10}	-0.037 (0.006)	
α_{20}		0.005 (0.004)
Test of overident. restrict.	12.391	
p-value	(0.949)	
R^2	0.392	0.463
n	38	

Standard errors are both heteroscedastic consistent and robust to autocorrelation: the disturbance terms are specified as a second order moving average process.

Table 7: Elasticities at the sample mean from
the semi-reduced system (standard errors in parentheses)

	parameters	P-Value
ε_{AA}	-0.394 (0.130)	[0.002]
ε_{AT}	-0.184 (0.078)	[0.000]
ε_{TT}	-0.563 (0.081)	[0.018]
ε_{TA}	-0.396 (0.162)	[0.015]
ε_{AY}	1.813 (0.447)	[0.000]
ε_{TY}	0.602 (0.298)	[0.043]

Standard errors have been computed using the delta method.

Table 8: Variation (%) in Alcohol (DCA) and Tobacco
(DCT) expenditure when Alcohol price grows at 3% per year

Year	DCA	DCT
2003	-0.124	-0.449
2004	-0.966	-0.455
2005	-0.121	-0.449
2006	-1.388	-0.496
2007	-1.046	-0.496
2008	-1.081	-0.508
2009	-1.117	-0.520
2010	-1.155	-0.533
2011	-1.194	-0.546
2012	-1.235	-0.560
2013	-1.277	-0.575
2014	-1.320	-0.590
2015	-1.365	-0.605
2016	-1.411	-0.622

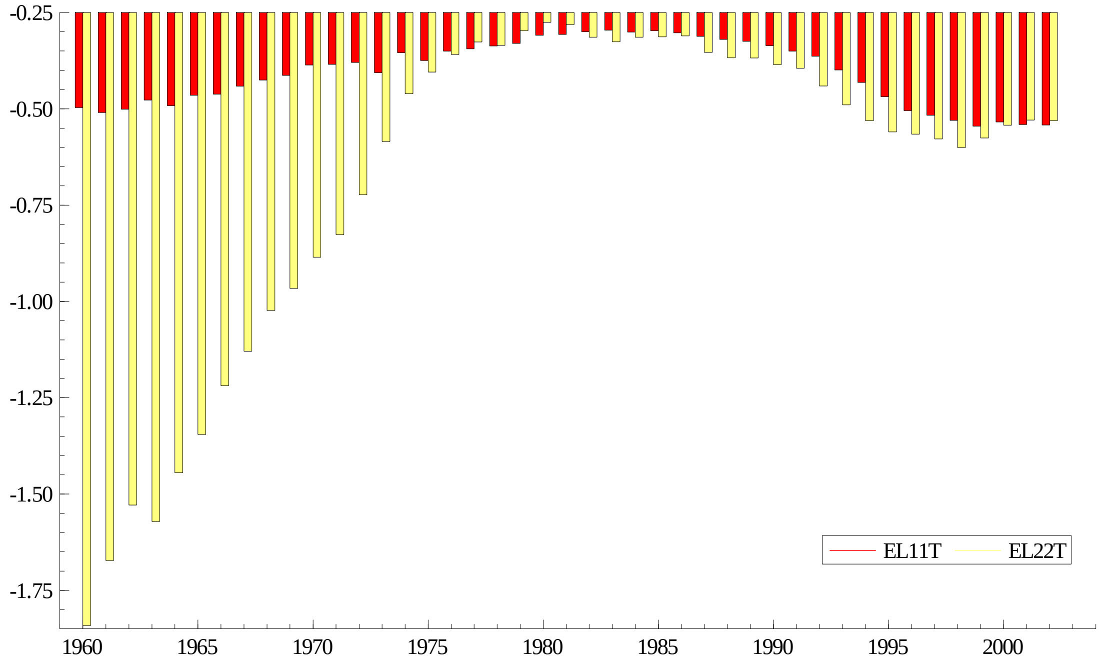

Figure 2: Own Price Elasticities of Demand: Alcohol (1) and Tobacco(2)

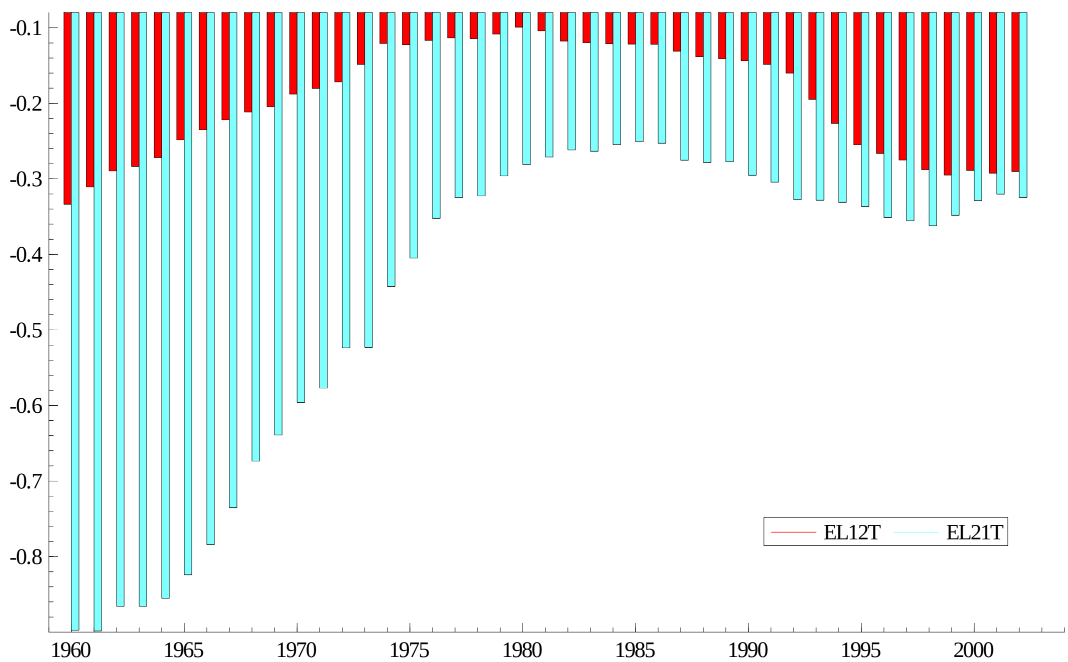

Figure 3: Cross Price Elasticities for Alcohl (1) and Tobacco (2)

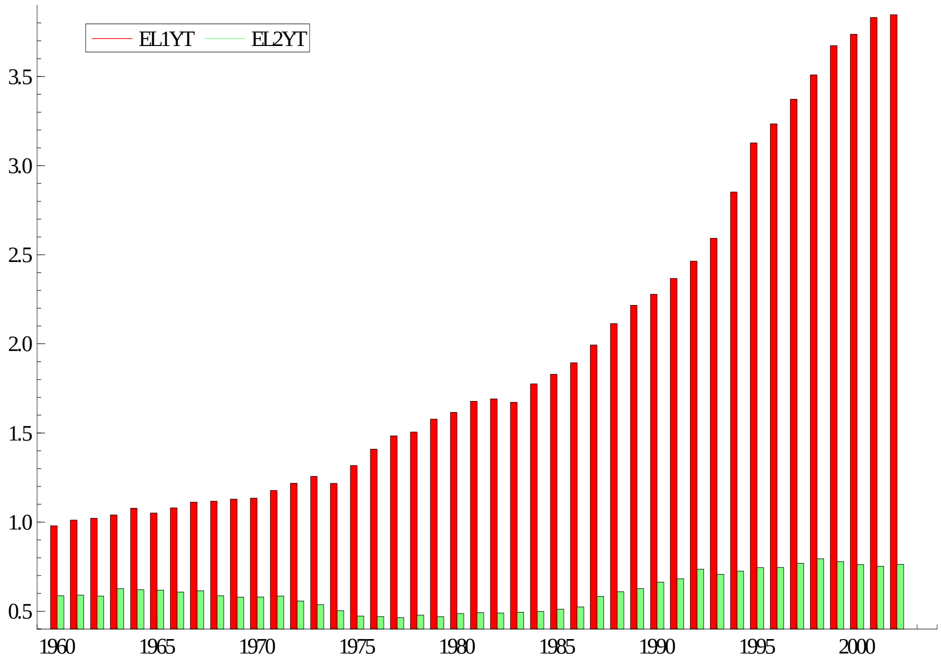

Figure 4: Income Elasticities for Alcohol (1) and Tobacco (2)

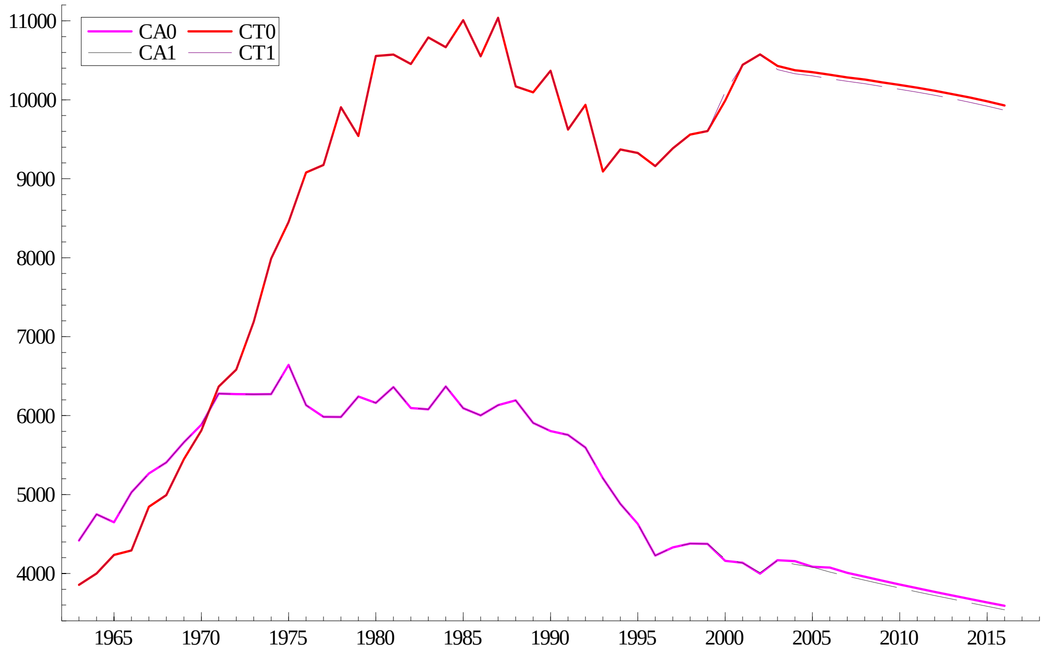

Figure 5: Effects of a change in Alcohol price on Alcohol and Tobacco expenditure (millions of Euros 1995). CA0, CT0 = levels of alcohol (CA0) and tobacco (CT0) expenditure assuming a growth rate in real prices of both goods, from 2003 to 2016, equal to the past trends in prices. CA1 = level of Alcohol expenditure assuming a growth rate of 3 % per year in Alcohol price.