Alcohol-tobacco tax policy, household spending and mortality: a microsimulation analysis on French data

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February 2006

Abstract

The main goal of this paper is to measure the impact of increasing alcohol and tobacco taxes, on the consumption of these products and the induced mortality. To do this we use a microsimulation model of French household spending, to compute the economic results associated with different tax policies. The estimation of the decrease in mortality associated with various levels of tax rate increase, shows that an increase of x% in specific taxes on alcoholic products (excise duties) induces a decrease in mortality equivalent to a monetary discounted return standing around x billions euros ; the "monetary efficiency" of increasing taxes on tobacco products is 50% greater : an increase of x% in specific tobacco taxes induces a decrease in mortality equivalent to a monetary discounted return standing around 1.5x billions euros. From a more general point of view, all the results obtained in the paper underline the difficulty to obtain consequent reductions in consumption of tobacco and alcoholic products, using only tax policies.

JEL : D12, H31, I12, I18

Keywords : Alcohol, Tobacco, Morbidity, Tax Policy, Microsimulation

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1. - Introduction

In France, each year, approximately 45000 people die of the consequences of alcohol and 60000 of tobacco. Since 2000, the various governments try to reach the objective of a strong alcohol and tobacco consumption decrease in order to reduce mortality and morbidity and their social cost. The French policy mostly relies on taxes increases (particularly for tobacco) but is accompanied by various measures limiting advertising and regulating sales conditions.

Our purpose is to evaluate the French public policy in regard to the objectives announced by the law on public health (August 9, 2004). The objective, regarding tobacco is "*to lower the prevalence of smoking (daily smokers) from 33% to 25% for men and from 26% to 20% among women before 2008 (while aiming first young people and social categories with strong prevalence)*". Regarding alcohol the objective is to reach "*a decrease in average annual consumption per inhabitant of 20%, from 10.7 litre per year per inhabitant in 1999 to 8.5 litre by 2008"*.

The French public policy was particularly harsh regarding tobacco. Two strong taxes increases took place in October 2003 and January 2004, (+ 4% and +1.75%), carried the price of the red Marlboro packet from 3.90 € to 4.60 € and then to 5 €. Consumption adjusted to price and decreased, in the average, by 35%. The same phenomenon can be observed with alcohol even though taxes increases were less brutal.

Our paper uses an econometric model of micro-simulation in order to measure the impact of the variations of taxes, on the prices and the levels of consumption. The principle is simple. It rests on the fact that the tax reforms involves price changes which affect the consumer through two effects: a "price effect" which describes the impact of the price change to unchanged behaviour and a "quantities effect" which describes the impact of the modifications of behaviours induced by the shock on the prices (reduction or even smoking cessation). This second effect, measured by the direct compensated price-elasticity, is the central element of the model. By using the data survey provided in 2000 by INSEE and without taking account of the existence of the illegal market, we calculate the price-elasticity for tobacco and alcohol (-0.522). This means that when the price increases by 10%, the associated demand decrease by 5.22%. From this estimate, one can easily realize two types of simulation: to evaluate the impact of tax shocks of various widths (+10%, +20%, +30%) on the consumption and to identify the extent of the tax shocks necessary to reach various consumption's targets (-5%, -10% and -15%).

The second part of the paper is dedicated to the impact of consumption's reduction on mortality. Our modelization rests on the assumption that the decrease of average consumption generates a fall of the number of death. We take into account (in particular in the case of tobacco) the fact that some consumers decrease their consumption when others quit smoking. In order to produce comparable estimations we put a value on the number of years of life saved by the price raise, using the conventional value for a year of life and a discount rate equal to 6%.

The results show that a 10% increase in specific taxes on alcoholic products induces a decrease in mortality equivalent to a monetary discounted return standing around 10 billion euros; comparing with alcohol, the "efficiency" of increasing taxes on tobacco products is

50% higher: a 10% increase of specific tobacco taxes induces a decrease in mortality equivalent to a monetary discounted return standing around 15 billion euros. In terms of mortality, one can retain as an approximation that – for moderate increases in excise duties – a 10% tax increase on alcohol/tobacco products allows saving about 380/450 lives each year.

From a public policy point of view, our estimations highlight the ambitiousness of the public authorities' health targets concerning tobacco consumption. It is clear from our simulations, that the announced public health target cannot be achieved by using only the tax policy tool.

2. - Presentation of data

2.1 - INSEE Family Expenditure survey

The objective of the Family Budget Survey (BDF) is to reconstitute global household accounting: it collects, from a sample of 10 000 households, the entirety of spending, non monetary consumption and income, with a full set of socio-demographics variables.

Its catalogue of spending data is the main interest of this survey: through a list including from 400 to 1000 items (depending of the year), the exact nature of expenditures and the corresponding amounts are registered. The field of the survey is as large as possible: all spending is included, even household expenditures which are not included in national accounts: taxes, insurance premiums, housing renovation spending, inter-household and intra-household transfers, purchases of second hand goods etc.). In addition to monetary spending, the survey includes information on various consumptions which do not result from household's purchases, essentially auto consumption.

A survey of household's resources is attached to that of spending, essentially because for the analysis of consumption, income is generally used as an explanatory variable. However, since 1989, income represents the main interest of the survey, aside from spending data. All kind of incomes are registered: those which are taxable or not, social allowances, windfall gains etc.

Data collection for each of the surveys is spread over 12 months – in 8 waves of 6 weeks – in order to eliminate seasonal spending patterns. Two instruments are used to collect the data:

(i) a questionnaire, to be filled during the interviewer's visits, the objective of which is to register the household's socio-demographic characteristics, its income as well as its regular or major expenses.

(ii) a book account is given to each member of the household over 14, in which to register, during two weeks, all daily spending as well as small irregular expenses.

2.2 - INSEE's monthly price index

The main objective of monthly price indexes from the French statistical institute (Insee) is to provide evaluations of price variations for various sets of products. The reference population is made up of all French households, even though an index of urban households whose head is working class or employee (*i.e.* 25% of the population) continues to be published.

For all index, the index value is set equal to 100 for the year of reference. Three successive changes concerning the year of reference have been made since 1979: 1980=100, 1990=100 and eventually 1998=100. Each time, the list of items, was also changed: 296 items before 1990, 265 between 1990 and 1997 and 159 since 1998. A weighting is associated with each published index, in order to allow computing indexes of various baskets of consumer goods.

These weights are determined by INSEE and are recalculated once a year after the publication of December's index. The weighting is proportional to the reference value of household purchases for a given year *t*, beginning with the consumer weight observed in *t-2*, which is revised incorporating price movements operated between *t*-2 and *t*-1. The weightings of year *t* are then the weights of year *t-2* at year *t-1's* price.

As the price index presents a level of disaggregation greater than macroeconomic data, INSEE uses the most recent statistics from microeconomic surveys (mainly professional sources and BDF) in order to compute the disaggregated weights to the desired level of detail.

2.3 - Creation of a harmonised database

As the BDF survey does not include any information on quantities consumed by households in addition to spending, it is impossible to get the *unit values* from this survey. It is thus necessary to match the previous information concerning household expenditures, with an exogenous price data set.

To do this the only available source are the INSEE indexes. However, the main difficulty in matching the BDF survey and the INSEE price index is that the former includes 400 items to be compared to the 160 items for the latter. It is thus necessary to create a bridge between the two lists of items enabling simultaneous work with the two databases. The outcome of these constraints is a breakdown of tobacco and alcoholised products into four different items: *(i)* wine and champagne, *(ii)* strong alcoholic beverages, *(iii)* ciders and beers and *(iv)* tobacco. These four categories constitute the "key of the bridge" between the price index and the BDF survey and the starting point of our harmonized data set for the microsimulation.

3. - Microsimulation of a tax shock

We describe hereafter our fiscal framework and the computation of the behavioural core of our model.

3.1 - Fiscal modelling

Ad valorem taxes, which represent a percentage of to the value of the commodity, are the taxes most frequently encountered in French fiscal environment. For such taxes, an observation of the amounts spent allows to calculate the amount of the tax. The problem is somewhat different for tobacco and alcohol products, because most of the indirect taxes on these commodities are *excise duties,* which are usually assessed by reference to the quantity of the product *i.e.* expressed by unit of commodity. For this kind of taxes, observation of quantities, in addition to spending, is of course required (as a commodity subject to an excise duty is also subject to VAT, one must still observe spending for an exhaustive fiscal modelling of the commodity). As stated above, the BDF survey does not register the quantities consumed by households. We then need to convert excise duties in an implicit *ad valorem* tax rate in order to mimic a standard *proportional* tax pattern.

3.1.1 - Conversion of *excise duties* into proportional tax rates

Let us start from the basic case of a commodity subject to an excise duty a and a VAT rate t. The price including taxes p_{ttc} can be written as a function of the price excluding taxes p_{ht} :

$$p_{ttc} = (1 + t)(p_{ht} + a)$$

Let us now write :

$$p_{ttc} = (1+t)(1+\tau)p_{ht}$$

where

$$\tau = \frac{a}{p_{ht}}$$

represents the implicit proportional rate corresponding to the additive parameter a. For the computation of τ, one notes:

$$D_M = p_{ttc}Q$$

and

$$R_M = aQ$$

with Q representing the quantity consumed of the commodity, D_M the observed spending as it appears in the national accounts and R_M the fiscal receipt originating from excise duty a as it appears in the French ministry of finance account.

When unit prices and quantities are unknown, the ratio of the two preceding expressions allows calculation of the implicit rate, from national household consumption and fiscal receipts:

$$\frac{D_M}{R_M} = \frac{p_{ttc}}{a} = \frac{(1+t)(p_{ht}+a)}{a} = (1+t)\left(\frac{p_{ht}}{a}+1\right)$$

We obtain then:

$$\tau = \frac{1}{\frac{D_M}{R_M(1+t)}-1}$$

The implicit proportional tax rate is thus easily computable from observable data (national consumption and fiscal receipts). In the same manner we deduce the unit price from the excise duty, and lastly the quantity consumed.

3.1.2 - Calculation of implicit tax rates for alcoholized beverages

Wines

To calculate τ_w, we start from receipts originating in excise duties on wine for the year 2000, and the corresponding expenditure, to deduce the unit price (all taxes included) for one hectolitre of wine, then the price excluding tax. The calculation of τ_w is then immediate; the different steps of the calculation are given in the table bellow.

Excise duties (€ per hl)	3.35
Households expenditures, wine (BDF, million €)	5 558
Total spending in wine (million €)	7 717
Cover rate (wine)	72.01%
Tax receipts on wine (million €)	127.00
Implicit tax rate, wine	2.01%
Price excluding taxes (€, per hl)	166.86
Price excluding taxes (€, per litre)	1.67
Price including taxes (€, per litre)	2.04

Table 1 – Calculation of the implicit tax rate on wine

Beers

Beers are subject to an additive consumption tax b assessed by reference both to the alcoholic strength and the quantity of the product. We assume here that the average alcoholic strength for beers is 4.5%. To calculate τ_b, the method is then identical to that used for wines. Starting from 2000 expenditures and associated receipts, we deduce the price all taxes included of one hectolitre of beer, the price excluding taxes and eventually τ_b. Using the formula stated above for the implicit tax rate, we get a value 40.09% for τ_b ; the different steps of the calculation appear in the following table:

Tax on beer (€ per hl/degree of alcohol)	2.6
Average alcoholic strength for beers (hypothesis)	4.50%
Tax receipts on beer (million €)	359
Tax on beer (per hl at 4.5°)	11.7
Households expenditures on beer (BDF, million €)	1 143
Total spending in beers (million €)	1 500
Cover rate (beer)	76.15%
Implicit tax rate, beer	40.09%
Price excluding taxes (€, per hl)	29.19
Price excluding taxes (€, per litre)	0.29
Price including taxes (€, per litre)	0.49

Table 2 –Calculation of the implicit tax rate on beer

Spirits

This class of products includes all alcoholic beverages except wines and beers. For this class of products we need to consider two additive taxes: the consumption tax a on alcoholic beverages and the CNAM[1] contribution denoted by c. We calculate implicit tax rates τ_a and τ_c with the following formula:

$$\tau_a = \frac{1}{\frac{D_M}{R_a(1+t)} - \frac{\delta a+c}{\delta a}}$$

$$\tau_c = \frac{1}{\frac{D_M}{R_c(1+t)} - \frac{\delta a+c}{c}}$$

The aggregate implicit tax rate τ_{ac} for a commodity subject to the two previous excise duties is simply computed as the sum of the implicit tax rates τ_a and τ_c:

$$\tau_{ac} = \frac{\delta a+c}{p_{ht}} = \frac{1}{\frac{D_M}{(R_a+R_c)(1+t)-1}} = \tau_a + \tau_c$$

Let us remark at this point, than the consumption tax a on alcoholic beverages applies by hectolitre of *pure alcohol*, while the CNAM contribution applies by hectolitre of the *finished product*. It is wrong here to make the hypothesis of an arbitrary alcoholic strength for spirits (as we did for beers) as it is possible to calculate an average alcoholic strength for this class of products. Indeed, fiscal receipts for the two specific taxes are calculated according to the following formulas:

[1] CNAM is the acronym for the french National Health Public Fund

$$R_c = cQ$$

and

$$R_a = a\delta Q$$

We thus have,

$$\frac{R_c}{R_a} = \frac{c}{a\delta}$$

where δ represents the average alcoholic strength:

$$\delta = \frac{R_a}{R_c}\frac{c}{a}$$

To calculate τ_{ac}, we apply the same method that we previously applied for wines and beers. We use the households spending and the fiscal receipts collected by the Government; the different steps of the calculation appear in the following table:

Rate of value added tax (VAT)	19.60%
Consumption tax (€ per hl of pure alcohol)	1450
CNAM contribution (€ per hl)	130
Receipts from the consumption tax (million €)	1872
Receipts from the CNAM contribution (million €)	376
Average alcoholic strength	44.64%
Household spending in spirits (BDF, million €)	2 622
Total household spending in spirits (million €)	3 663
Implicit tax rate, CNAM (τ_c)	46.14%
Unit price, spirits, excluding taxes (€, per hl)	281.74
Unit price spirits, excluding taxes (€, per litre)	2.82
Price including taxes (€, per litre)	12.67
Implicit tax rate, consumption tax (τ_a)	229.73%
Aggregate implicit tax rate, spirits	275.87%

Table 3 – Calculation of the implicit tax rate on spirits

3.1.3 - Tobacco taxation

Tobacco taxation is a hybrid taxation including excise duties and *ad valorem* taxes simultaneously. Its relative complexity makes impossible to represent within the framework of our data. We thus adopt a simplified presentation of custom's duty, assuming that all smokers consume the reference brand of cigarettes (a legal definition adopted by the French ministry of finances) – *i.e.* for 2005 the class of cigarettes at 5 euros per pack of Marlboro red type– subject to a single *ad valorem* tax.

3.2 - Econometric estimation of the demand function for alcohol and tobacco

In order to perform robust and unbiased estimation of demand function for alcohol and tobacco, the econometrician must take into account the problem of zero consumption, which is important in our survey (53% for alcoholic beverages and 66% for tobacco). This can have two not concurrent interpretations:

- First, the household does not consume a commodity, either because of its preferences or because of a too high price, (a classic "corner solution" in consumer's utility maximization). Typical demand models in literature do not consider this solution, which weaken their theoretical grounding
- Second, during the survey period, household did not purchase the commodity, either because it had it in stock – as for some alimentary products for example – or because of unstable preferences– as for certain leisure commodities or services.

In both cases, consumption or non-consumption is linked to the socio demographic status of the household: the stock effect is greater in aged households, the distinction smoker/non smoker is correlated to the household's level of education etc. Not taking into account these effects when estimating the demand function, induces a bias when calculating the price elasticity. For these reasons, we choose to estimate demand function using a Heckman (heckit) selection model. This methodological choice requires two comments:

- On the one hand, the variation in estimates is minimal between an MCO estimation and an estimation using heckit. Nevertheless, such biases obviously justify their correction, in order to provide the best estimators.
- On the other hand, after a tax induced price change, the demand can change in two directions. When the price increases, a household may reduce its consumption until this becomes nil. The household exits the market. When the price decreases, some households start to consume the commodity and enter the market. The public authority is concerned by both modifications. Correcting the endogenous selection bias of the sample means ignoring the entry (exit) phenomenon. By proceeding with MCO, we estimate an elasticity that represents the average demand response for households having reported consumption or leaving and re interring the market.

At first glance it would appear that MCO are good enough for measuring public policy's impact. However, by adopting this framework, we must use a microsimulation model with an explicit computation of the market entry and eviction process.

Thus, even if we don't know *ex-ante* the contribution of this process, it requires the use of complex techniques resembling those we believed to have avoided when choosing to estimate by MCO. Taking this phenomenon into account for our estimations but not in our simulations would then be useless. At this stage we prefer to adopt the hypothesis that the entry and eviction process only plays marginally for the microsimulation of indirect taxation.

We retain a quadratic almost ideal demand system specification (Qaids) for the Marshallian functions of demand, expressed here in the form of budget shares (households are indexed by $h = 1, ..., H$) :

$$w_h = X_h'\varphi = \alpha_h + \gamma \ln\left(\frac{p}{P^*}\right) + \beta \ln\left(\frac{X_h}{P^*}\right) + \lambda\left[\ln\left(\frac{X_h}{P^*}\right)\right]^2 + u$$

where w_h designates the budget share for alcohol and tobacco of household h, $\ln p/P^*$ the log of the relative price index of the commodity I (with p the price index of alcohol and tobacco and $\ln P^*$ a Stone price index reflecting the general price level in the economy), X_h the total spending of household h and α_h a constant. Household heterogeneity contributes greatly to the explanation of consumer behaviour, so we introduce different variables describing this heterogeneity. Thus we will suppose that the constant for our model, α_h, depends linearly upon socio demographic status:

$$\alpha_h = \alpha + m'_h \alpha_h$$

$$m'_h = \{\text{age of the head of the household, socio-economic status of the head of the household, household structure, geographic location, seasonality}\}$$

The age of head of household is a continuous variable. The index of socio-economic status is divided into six categories: farmers, self-employed, middle professions, executives, workers and inactive. Household composition is divided into four categories: number of children under 2, those between 2 and 4, those between 4 and 16, then the number of persons in the household over 16. Geographic localisation includes four zones: rural, cities other than Paris and its suburbs, Paris agglomeration, and Paris *intra-muros*.

We note w^*_h the latent budget share of households h in alcohol and tobacco, and z^*_h a latent dummy, equal to 1 if the household consumed the commodity during the observation period, if not 0 :

$$\begin{bmatrix} w^*_h \\ z^*_h \end{bmatrix} = \begin{bmatrix} X'_h\varphi \\ W'_h\gamma \end{bmatrix} + \begin{bmatrix} u \\ v \end{bmatrix}, \begin{bmatrix} u \\ v \end{bmatrix} \sim \text{NID}\left(0; \begin{bmatrix} \sigma^2 & \rho\sigma \\ \rho\sigma & 1 \end{bmatrix}\right),$$

Observed variables are w_h and z_h, and linked to w^*_h and z^*_h as follows:

$$\begin{array}{llll} w_h = w^*_h & \text{if} & w^*_h > 0\ ; & w_h = 0 \quad \text{otherwise} \\ z_h = 1 & \text{if} & z^*_h > 0\ ; & z_h = 0 \quad \text{otherwise} \end{array}$$

The dependent variable of the selection equation, z_h, is a dummy worth 1 if the household h purchased alcohol and tobacco during the survey, 0 if not. As mentioned above, consuming or not is intimately linked to socio demographic characteristics of the household. Thus we have:

$$W'_h = \{\text{age of the head of the household, socio-economic status of the head of the household, household structure, geographic location, seasonality}\}$$

We obtain a direct price elasticity compensated for the item tobacco-alcohol of -0.522, and significant (standard error = 0.097). Thus, when the price of alcohol/tobacco increases by 10%, the associated demand decreases by 5.22%. Moreover, the associated Mills ratio (-0.117), statistically significant, demonstrate the existence of a selection bias on alcohol and tobacco, which has been corrected by the econometric method that we applied.

3.3 - Analytical description of reform

Reform of indirect taxation leads to price variations which have repercussions on the consumer. The impact of this reform can be decomposed traditionally into two effects :

- A '*pure price effect*' describing the impact of a price variation with an unchanged behaviour. In this case a price variation of x%, induced by a change in value of one or several fiscal parameters, leads a x% variation in spending.
- A *pure quantity effect* which describes the impact on the quantity consumed of behavioral changes induced by the price shock.

– The combination of both effects is described by the direct compensated price elasticity. It is obviously more realistic. We specify below the price and spending variations associated with a reform.

Alcohol and tobacco are subject to a taxe rate *ad valorem t* and to an excise tax *a* transformed into proportional rate τ using the method presented above.

The price of goods (tax included) before reform (exponent 0 designating thereafter the initial fiscal situation and 1 the situation after reform) can be written in the following general formulation:

$$p_{ttc}^0 = (1 + t^0)(p_{ht} + a^0) = (1 + t^0)(1 + \tau^0)p_{ht}$$

Spending (tax included) for this commodity is:

$$D_{ttc}^0 = p_{ttc}^0 Q = (1 + t^0)(1 + \tau^0)p_{ht}Q$$

and the expenditure HT :

$$D_{ht}^0 = p_{ht}Q$$

where Q designates quantity of the commodity consumed.

The amount of the tax T produced by the excise tax and the *ad-valorem* rate before reform of the commodity is:

$$T^0 = D_{ttc}^0 - D_{ht}^0 = (1 + t^0)(1 + \tau^0)p_{ht}Q - p_{ht}Q = D_{ht}^0(t^0 + \tau^0 + t^0\tau^0)$$

$$\Leftrightarrow T^0 = D_{ttc}^0 \frac{t^0}{(1+t^0)(1+\tau^0)} + D_{ttc}^0 \frac{\tau^0}{(1+t^0)(1+\tau^0)} + D_{ttc}^0 \frac{t^0\tau^0}{(1+t^0)(1+\tau^0)}$$

The first term of the right hand member of the preceding equation represents the amount of tax produced by the *ad valorem* rate; the second the amount coming from the excise tax and the third the amount of '*tax on tax'* i.e the amount generated by the *ad valorem* rate applied on the excise tax.

Following a reform modifying the value of the *ad valorem* rate and the excise tax, the associated price variation is:

$$\Delta p_{ttc} = \frac{p_{ttc}^1 - p_{ttc}^0}{p_{ttc}^0} = \frac{(1+t^1)(1+\tau^1)-(1+t^0)(1+\tau^0)}{(1+t^0)(1+\tau^0)}$$

By multiplying this last expression by the HT spending it becomes:

$$D_{ttc}^1 = D_{ttc}^0 + \left[\frac{(1+t^1)(1+\tau^1)}{(1+t^0)(1+\tau^0)} - 1\right]D_{ttc}^0$$

This expression defines the spending after reform as a function of spending before the reform. It does not include behavioural reaction. By introducing price elasticity ε estimated in the preceding section, comes:

$$D_{ttc}^1 = D_{ttc}^0 + \left[\frac{(1+t^1)(1+\tau^1)}{(1+t^0)(1+\tau^0)} - 1\right](1 + \varepsilon)D_{ttc}^0$$

This last expression describes the spending variations after reform: for $\varepsilon = 0$, the spending after is equal to that before plus the price variation.

4. - Economic Impact of fiscal shocks

The purpose of this section is to analyze the impact of tax policies on alcohol and tobacco consumption.

4.1 - Simulations

Two types of simulation exercise are carried out. We first use the model presented in the previous section to compute the impact on alcohol and tobacco consumption of various tax shocks applied to these products. For alcohol products we modify the level of excise duties on wine, beer and alcohol – defined by the implicit proportional rates τ_w τ_b and τ_{ac} computed in section 3.1 – by successively imposing increases of +10%, +20% , +30% to the three implicit tax rates ; for tobacco we symmetrically simulate increases of +10%, +20% and +30% of the *ad valorem* tax. Then we reverse the model to identify the magnitude of tax shocks required to obtain decreases of -5%, -10% and -15% in tobacco and alcohol consumption.

The last BDF survey available dating from 2000, in the first step all numerical simulations are carried out with household behavior patterns from 2000 (gross simulations); in a second step the values obtained at the first step are converted to 2004 equivalent values.

4.2 - Results

4.2.1 - Gross simulations (year 2000)

Alcohol

In a standard way we evaluate global consumption of all types of alcoholized products (beers, wine etc.) by the equivalent number of litres of pure alcohol. The price of a litre of pure alcohol is calculated by dividing the *value* of the global consumption of alcoholized products, drawn from the BDF consumer survey, by the *volume* of the same global consumption evaluated from the *"average alcohol consumption in litres of pure alcohol per year and per person aged 15+"*, provided by the French National Institute of Statistic and Economic Studies (INSEE)[2] .

Table 4 below summarizes the results corresponding respectively to +10%, +20% and +30% increases in specific taxes on alcohol – as they are defined in section 3.1 by the implicit proportional rates – distinguishing the *price effect* alone from the *overall effect* which integrates behavioral adjustments involved in the increase of the alcoholized products.

We have calculated the price of a litre of pure alcohol, as being equal to €21.4 (including all taxes) in the year 2000; at this price households consume 687 million litres of pure alcohol per year, corresponding to an average of 14.2 litres per person aged 15 and over. A tax increase of +20% – for example – induces a shift from €21.4 to €22.48, of the price of a litre of pure alcohol corresponding to a price growth rate of +5,05% [3]; the result, *with unchanged*

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[2] Average alcohol consumption, litres of pure alcohol per person, field : adults aged 15 and over ; source : Insee, Department of Household Living Conditions (www.insee.fr/fr/ffc/figure/nattef06219.xls) ; by multiplying this series by the population aged 15 and over, we immediately obtain the annual global consumption of alcoholic products in litres of pure alcohol *i.e.* 687 million litres in 2000.

[3] This result summarizes the main properties of spirits taxation: an increase of *x%* of excise duties eventually induces, under the hypothesis of an unchanged producer price setting behavior, a rise of about ¼ *x%* of the price of a litre of pure alcohol.

household behavior, is a proportional increase of +5,05% of the total value of household spending on alcohol, which rises from €14.7 billions to €15,44 billions. Eventually, this increase in the monetary value of consumption induces a rise of 13.43% in tax receipts associated with alcoholized products, corresponding to a benefit for the government budget of around €742 million.

However, the *downward adjustment of household consumption behavior* limits the effects described above; indeed, for a +20% tax increase, one obtains, after taking into account the consumption adjustments, an increase in total household spending for alcoholized products, which is no longer +5.05% but only +2.41%. The real consumption, *i.e.* the quantities, being adjusted downward after a price shock, the monetary value of consumption increases less than proportionally to the initial price shock ; for the same reason the tax receipts increase is no longer +13.43%, but only +8.30%, corresponding to a limited €460 million benefit for the government budget.

The total consumption of pure alcohol – after the tax shock and the induced household consumption adjustment – is then obtained simply by dividing the new value of household alcohol expenditure after the shock (€15.056 billions), by the new value of a litre of pure alcohol (€22.48), leading to an evaluation of 670 million litres of pure alcohol per year *i.e.* 13.84 litres/year/person aged 15+.

SIMULATIONS –ALCOHOL TAX SHOCKS	Increase +10%	Increase +20%	Increase +30%
BEFORE THE SHOCK			
Price of pure alcohol per litre (€ including taxes)		21.40	
Alcohol spending (millions €)		14 701	
Tax receipts (millions €)		5 522	
Consumption of alcoholized products (millions of litres of pure alcohol)		687	
Consumption of litres of pure alcohol per year/person 15+		14.20	
AFTER THE SHOCK AND WITHOUT BEHAVIOR ADJUSTMENT (*i.e.* price effect only)			
Price of pure alcohol per litre (€ including taxes)	21.93	22.48	23.01
Variation in %	2.48%	5.05%	7.53%
Variation in €	0.53	1.08	1.61
Alcohol spending (millions €)	15 066	15 443	15 809
Tax receipts (millions €)	5 887	6 264	6 630
Variation in %	6.61%	13.43%	20.05%
Variation in millions €	365	742	1107
AFTER THE SHOCK WITH BEHAVIOR ADJUSTMENT (price and quantity effects)			
Alcohol spending (millions €)	14 876	15 056	15 231
Variation in %	1.19%	2.41%	3.60%
Tax receipts (millions €)	5 751	5 982	6 203
Variation in %	4.15%	8.33%	12.33%
Variation in millions €	229	460	681
Consumption of alcoholized products (millions of litres of pure alcohol)	678	670	662
Variation in %	-1.26%	-2.51%	-3.66%
Consumption of litres of pure alcohol per year/person 15+	14.02	13.84	13.68

Table 4 – Tax shocks on alcoholized products (year 2000)

Table 5 below provides the results obtained by simulating the model the opposite way, in order to identify the value of tax shocks required to reach different targets in terms of alcohol consumption. The table reads identically to table 4. For example, a decrease of -10% in the total yearly consumption of pure alcohol can only be obtained by a +90% increase in the tax on alcoholized products; to get a reduction of -15% of this consumption a rise in specific taxes of +160% is required.

SIMULATIONS – ALCOHOL CONSUMPTION TARGETS	Decrease -5%	Decrease -10%	Decrease -15%
Required increase in tax on alcohol	+45%	+90%	+160%
BEFORE THE SHOCK			
Price of pure alcohol per litre (€ including taxes)		21.40	
Alcohol spending (millions €)		14 701	
Tax receipts (millions €)		5 522	
Consumption of alcoholized products (millions of litres of pure alcohol)		687	
Consumption of litres of pure alcohol per year/person 15+		14.20	
AFTER THE SHOCK AND WITHOUT BEHAVIOR ADJUSTMENT (*i.e.* price effect only)			
Price of pure alcohol per litre (€ including taxes)	23.83	26.27	30.06
Variation in %	11.38%	22.76%	40.46%
Variation in €	2.44	4.87	8.66
Alcohol spending (millions €)	16 374	18 046	20 650
Tax receipts (millions €)	7 195	8 867	11 471
Variation in %	30.30%	60.58%	107.73%
Variation in millions €	1673	3345	5949
AFTER THE SHOCK WITH BEHAVIOR ADJUSTMENT (price and quantity effects)			
Alcohol spending (millions €)	15 501	16 300	17 545
Variation in %	5.44%	10.88%	19.34%
Tax receipts (millions €)	6 538	7 491	8 915
Variation in %	18.39%	35.66%	61.43%
Variation in millions €	1015	1969	3392
Consumption of alcoholized products (millions of litres of pure alcohol)	650	621	584
Variation in %	-5%	-10%	-15%
Consumption of litres of pure alcohol per year/person 15+	13.44	12.83	12.06

Table 5 – Tax shocks required to reach different targets of alcohol consumption (year 2000)

Tobacco

For tobacco we proceed with the same types of simulation as for alcohol. Household spending for tobacco being extracted from the BDF survey, one needs to know the number of packs of cigarettes consumed each year, to be able to compute the price of a "normalized" pack of cigarettes.

For the year 2000, Hill and Laplanche [2005] evaluate at 82514 million the number of manufactured cigarettes, 6976 million rolled cigarettes and 6622 tons of bulk tobacco, the total yearly tobacco consumption ; by converting the bulk tobacco into cigarettes, on the basis of 0.8g for a cigarette (*cf.* Hill and Laplanche [2005]), we obtain a total yearly consumption of 4888 million "normalized" packs of 20 cigarettes, *i.e.* a price per pack of €2.39 (corresponding to €11701 million divided by 4888).

Using now the data provided by INSEE [4], in order to get another estimation, one arrives at a consumption of 4.6g of tobacco per day and per person 15+ (48.38 million people in 2000) *i.e.*, with the same conventions as above, 5077 million normalized packs of cigarettes corresponding to a price of €2.3 for a normalized pack. Considering the closeness between the two estimates, we decided to keep the latter in order to preserve the INSEE homogeneity of the data.

The results corresponding to various tax shock simulations on tobacco products are summarized in Table 6 below. Table 7 gives, as for alcohol, the tax increases required to achieve reductions of -5%, -10% and -15% in quantities consumed. Conversion of grams into number of cigarettes or number of packs is done on the commonly agreed basis of 0.8g of tobacco per cigarette and 20 cigarettes per pack.

SIMULATIONS – TOBACCO TAX SHOCKS	Increase +10%	Increase +20%	Increase +30%
BEFORE SHOCK			
Price of a normalized pack of cigarettes (€)	2.30		
Tobacco spending (millions €)	11 701		
Tax receipts (millions €)	5 521		
Total tobacco consumption (millions of packs of cigarettes)	5 077		
Grams of tobacco per year/person 15+	1679		
Cigarettes per day/person 15+	5.75		
AFTER THE SHOCK AND WITHOUT BEHAVIOR ADJUSTMENT (*i.e.* price effect only)			
Price of a normalized pack of cigarettes (€)	2.39	2.47	2.56
Variation in %	3.60%	7.33%	10.99%
Variation in €	0.08	0.17	0.25
Tobacco spending (millions €)	12 122	12 558	12 987
Tax receipts (millions €)	5 942	6 378	6 807
Variation in %	7.63%	15.53%	23.30%
Variation in millions €	421	857	1286
AFTER THE SHOCK WITH BEHAVIOR ADJUSTMENT (price and quantity effects)			
Tobacco spending (millions €)	11 902	12 111	12 316
Variation in %	1.72%	3.50%	5.25%
Tax receipts (millions €)	5 834	6 151	6 455
Variation in %	5.68%	11.41%	16.92%
Variation in millions €	314	630	934
Total tobacco consumption (millions of packs of cigarettes)	4 985	4 896	4 814
Variation in %	-1.81%	-3.56%	-5.17%
Grams of tobacco per year/person 15+	1649	1619	1592
Cigarettes per day/person 15+	5.65	5.55	5.45

Table 6 – Tax shocks on tobacco products (year 2000)

[4] Consumption of tobacco expressed in grams per adult (15 and over) and per day. Source: Insee, National Accounts; Gustave Roussy institute, Department of Epidemilogy & Biostatistics. Data available since 1951 : www.insee.fr/fr/ffc/figure/nattef06212.xls

One can see in table 7 that moderate positive tax shocks are unable to induce significant decreases in tobacco consumption. This is one of the main results of the paper. In fact an increase of +65% of tobacco taxes is required to obtain a reduction of -10% of the global consumption; the tax rise must be +110% to achieve a reduction of -15%.

SIMULATIONS – TOBACCO CONSUMPTION TARGETS	Decrease -5%	Decrease -10%	Decrease -15%
Required increase in tax on tobacco	+30%	+65%	+110%
BEFORE SHOCK			
Price of a normalized pack of cigarettes (€)		2.30	
Tobacco spending (millions €)		11 701	
Tax receipts (millions €)		5 521	
Total tobacco consumption (millions of packs of cigarettes)		5 077	
Grams of tobacco per year/person 15+		1679	
Cigarettes per day/person 15+		5.75	
AFTER THE SHOCK AND WITHOUT BEHAVIOR ADJUSTMENT (*i.e.* price effect only)			
Price of a normalized pack of cigarettes (€)	2.56	2.86	3.24
Variation in %	10.99%	23.94%	40.51%
Variation in €	0.25	0.55	0.93
Tobacco spending (millions €)	12 987	14 502	16 441
Tax receipts (millions €)	6 807	8 322	10 261
Variation in %	23.30%	50.74%	85.86%
Variation in millions €	1286	2801	4740
AFTER THE SHOCK WITH BEHAVIOR ADJUSTMENT (price and quantity effects)			
Tobacco spending (millions €)	12 316	13 040	13 967
Variation in %	5.25%	11.44%	19.36%
Tax receipts (millions €)	6 455	7 483	8 717
Variation in %	16.92%	35.54%	57.89%
Variation in millions €	934	1 962	3 196
Total tobacco consumption (millions of packs of cigarettes)	4 814	4 565	4 313
Variation in %	-5%	-10%	-15%
Grams of tobacco per year/person 15+	1592	1510	1426
Cigarettes per day/person 15+	5.45	5.17	4.88

Table 7 – Tax shocks required to reach different targets of tobacco consumption (year 2000)

4.2.2 - Simulations adjusted to year 2004

Up to this point we have carried out simulations allowing us to evaluate the impact, on the quantities consumed, of tax increases taking place in year 2000: then the previous tables describe *what would have occurred in the year 2000 if taxes had been increased*. Considering that the last BDF survey available is the one of 2000, it is not possible to do better in terms of microsimulations. In order to take into account both the population growth and the recent evolution of tobacco/alcohol prices, we have stalled all the preceding simulations by using year 2004 – instead of year 2000 – as basis year[5]. We consider for this that estimated behavior for 2000 is still the same today, but we adjust the simulations to take prices and population evolution into account.

[5] Data required for an adjustment to 2005 are not yet available

In other words, we assume that household reaction, in terms of consumption of tobacco and alcohol, to a rise of *x%* in specific taxes, is proportionally the same with today's prices as with those of yesterday : thus, for example, if a +10% tax rise led to a decrease of -1.81% of the consumption of tobacco when the price of a normalized pack of cigarettes was €2.3, we assume that we would obtain exactly the same -1.81% decrease of the consumption if we increase the tax by +10% of a normalized pack the price of which is, for example, €3.

The adjustment to year 2004 has then been carried out taking the evolution of the population into account, but assuming that the portion of the population aged 15 and over within total population remains unchanged[6].

Alcohol

Household spending for alcoholized products being estimated by INSEE at €15.721 billions in 2004, one needs to obtain the quantities consumed in order to determine the price of a litre of pure alcohol in 2004. The "*number of litres of pure alcohol per year/person 15+"* provided by INSEE[7], is however only available up to 2003; we thus extrapolate to get an evaluation of the 2004 value. This leads us to estimate at 13.87 litres, the consumption of pure alcohol per year/person 15+ for year 2004, corresponding to a global yearly consumption of 689 million litres of pure alcohol. Computation of the ratio of the consumption expressed in euros to the consumption expressed in litres, allows us to evaluate at €22.82 the price of a litre of pure alcohol in 2004. Tables 8 and 9 below give the results of the tax simulations applied to alcohol products after the results have been adjusted to year 2004.

[6] Under this hypothesis the population aged 15 and over is evaluated at about 49.66 million in 2004

[7] Average alcohol consumption, litres of pure alcohol per person, field : adults aged 15 and over ; Source : Insee, Department of Household Living Conditions (www.insee.fr/fr/ffc/figure/nattef06219.xls)

SIMULATIONS –ALCOHOL TAX SHOCKS	Increase +10%	Increase +20%	Increase +30%
BEFORE THE SHOCK			
Price of pure alcohol per litre (€ including taxes)		22.82	
Population 15 and over (millions)		49.663	
Alcohol spending (millions €)		15 721	
Tax receipts (millions €)		5 905	
Consumption of alcoholized products (millions of litres of pure alcohol)		689	
Consumption of litres of pure alcohol per year/person 15+		13.87	
AFTER THE SHOCK AND WITHOUT BEHAVIOR ADJUSTMENT (*i.e.* price effect only)			
Price of pure alcohol per litre (€ including taxes)	23.39	23.97	24.54
Variation in %	2.48%	5.05%	7.53%
Variation in €	0.57	1.15	1.72
Alcohol spending (millions €)	16 111	16 514	16 905
Tax receipts (millions €)	6 296	6 698	7 089
Variation in %	6.61%	13.43%	20.05%
Variation in millions €	390	793	1184
AFTER THE SHOCK WITH BEHAVIOR ADJUSTMENT (price and quantity effects)			
Alcohol spending (millions €)	15 908	16 100	16 287
Variation in %	1.19%	2.41%	3.60%
Tax receipts (millions €)	6 150	6 397	6 633
Variation in %	4.15%	8.33%	12.33%
Variation in millions €	245	492	728
Consumption of alcoholized products (millions of litres of pure alcohol)	680	672	664
Variation in %	-1.26%	-2.51%	-3.66%
Consumption of litres of pure alcohol per year/person 15+	13.69	13.52	13.36

Table 8 – Tax shocks on alcoholized products

A rise of +10% in excise duties applied to alcoholized products does not reduce global pure alcohol consumption by more than -1,26%, consumption per capita decreasing from 13.87 to 13.69 litres per year, that is to say a limited shift of less than -0.2 litres per year/person. However, such a tax shock allows the government to obtain almost €250 million in supplementary tax receipts. A higher tax increase of +30% drives the consumption of pure alcohol to 13.36 litres per year/person, corresponding to a more significant decrease of about ½ litre per person/year; the tax receipts increase is then greater than €700 million.

It is interesting to compare these results with the one hundred target objectives annexed to the French Public Health Law of August 9, which targets a -20% decrease of the consumption of alcoholized products per *inhabitant*/year, from 10.7 litres in 1999 to 8.5 litres by 2008. Expressed in terms of litres of pure alcohol *per person 15+,* the target annexed to the Public Health Law is equivalent going from 15.1 litres per person in 1999 – corresponding to the data provided by INSEE for the year 1999 (*cf.* footnote *supra*) – to 12.08 litres in 2008 that is to say a -20% drop in consumption.

Table 10 clearly shows that the level of the tax shock permitting the convergence on the target of 12.08 litres is of such magnitude (more than +100%) that such a tax policy would be politically very difficult to implement. Table 9 shows, however, that a moderate +30% rise of taxes on alcohol, even if it would not permit reaching immediately the proclaimed target, would allow (by stimulating a significant drop of -25 million litres per year in the total consumption of pure alcohol *i.e.* a move from 13.87 to 13.36 litres per year/person aged 15+)

the Government to be in a position to reach the target within a relatively reasonable timeframe.

SIMULATIONS – ALCOHOL CONSUMPTION TARGETS	Decrease -5%	Decrease -10%	Decrease -15%
Required increase in tax on alcohol	+45%	+90%	+160%
BEFORE THE SHOCK			
Price of pure alcohol per litre (€ including taxes)		22.82	
Population aged 15 and over (millions)		49.663	
Alcohol spending (millions €)		15 721	
Tax receipts (millions €)		5 905	
Consumption of alcoholized products (millions of litres of pure alcohol)		689	
Consumption of litres of pure alcohol per year/person 15+		13.87	
AFTER THE SHOCK AND WITHOUT BEHAVIOR ADJUSTMENT (*i.e.* price effect only)			
Price of pure alcohol per litre (€ including taxes)	25.42	28.02	32.06
Variation in %	11.38%	22.76%	40.46%
Variation in €	2.60	5.19	9.24
Alcohol spending (millions €)	17 510	19 298	22 082
Tax receipts (millions €)	7 695	9 483	12 267
Variation in %	30.30%	60.58%	107.73%
Variation in millions €	1789	3577	6361
AFTER THE SHOCK WITH BEHAVIOR ADJUSTMENT (price and quantity effects)			
Alcohol spending (millions €)	16 576	17 431	18 762
Variation in %	5.44%	10.88%	19.34%
Tax receipts (millions €)	6 991	8 011	9 533
Variation in %	18.39%	35.66%	61.43%
Variation in millions €	1 086	2 106	3 628
Consumption of alcoholized products (millions of litres of pure alcohol)	652	622	585
Variation in %	-5%	-10%	-15%
Consumption of litres of pure alcohol per year/person 15+	13.13	12.53	11.78

Table 9 – Tax shocks required to reach different targets of alcohol consumption

Several lessons come to light from analysis of the results:

- The public administration's proclaimed objective of reducing pure alcohol consumption by 20% is very ambitious
- This target cannot by achieved by a tax shock alone, except if the Government is ready to pay the "political price" of an extremely high rise in the price of alcohol
- If a succession of calibrated tax shocks could, in theory, allow the Government to reach the health target, it would probably be more efficient – considering the distance between the present consumption and the targeted one – to use other instruments in addition to the fiscal tool.

The price of a normalized pack of cigarettes in 2004 – €3,46 – has been computed by simply applying to the price of the same item in 2000 – 2,30€ – the growth rate of the tobacco price index as provided by INSEE [8]. The price of a pack of cigarettes of the *most consumed brand* is

[8] Price of tobacco, Index 1970=100, Source : Insee, National Accounts; Gustave Roussy institute, Department of Epidemilogy & Biostatistics. Data available since 1951 : www.insee.fr/fr/ffc/figure/nattef06212.xls

given as an indication, to get something easier to handle than the price of a *normalized pack* of cigarettes. The real consumption (expressed in millions of packs of cigarettes) has been computed as above, starting from the consumption of tobacco in grams per day and per person aged 15 and over – given by INSEE (3,3g in 2004; *cf.* footnote *supra*) – and the population aged 15+, under the usual assumptions of 0,8g of tobacco per cigarette and 20 cigarettes per pack. We then deduced the consumption in value – tobacco spending in millions of euros – by multiplying the number of packs consumed per year, by the price of the normalized pack.

According to our simulations, the results of which are presented in tables 10 and 11 below, an increase of +30% in the specific taxes on tobacco has a limited impact on global tobacco consumption, which goes from 1205g per year/person 15+, to 1142g, corresponding to a limited decrease of about 5% .

SIMULATIONS – TOBACCO TAX SHOCKS	Increase +10%	Increase +20%	Increase +30%
BEFORE SHOCK			
Price of a normalized pack of cigarettes (€)		3.46	
Price of a pack of cigarettes of the most consumed brand (€)		5.00	
Population 15 and over (millions)		49.663	
Tobacco spending (millions €)		12 951	
Tax receipts (millions €)		6 110	
Total tobacco consumption (millions of packs of cigarettes)		3 739	
Grams of tobacco per year/person 15+		1 205	
Cigarettes per day/person 15+		4.13	
AFTER THE SHOCK AND WITHOUT BEHAVIOR ADJUSTMENT (*i.e.* price effect only)			
Price of a normalized pack of cigarettes (€)	3.59	3.72	3.84
Variation in %	3.60%	7.33%	10.99%
Variation in €	0.12	0.25	0.38
Price of a pack of cigarettes of the most consumed brand (€)	5.18	5.37	5.55
Variation in €	0.18	0.37	0.55
Tobacco spending (millions €)	13 417	13 900	14 374
Tax receipts (millions €)	6 577	7 059	7 534
Variation in %	7.63%	15.53%	23.30%
Variation in millions €	466	949	1 424
AFTER THE SHOCK WITH BEHAVIOR ADJUSTMENT (price and quantity effects)			
Tobacco spending (millions €)	13 174	13 405	13 631
Variation in %	1.72%	3.50%	5.25%
Tax receipts (millions €)	6 457	6 808	7 144
Variation in %	5.68%	11.41%	16.92%
Variation in millions €	347	697	1034
Total tobacco consumption (millions of packs of cigarettes)	3 671	3 605	3 545
Variation in %	-1.81%	-3.56%	-5.17%
Grams of tobacco per year/person 15+	1 183	1 162	1 142
Cigarettes per day/person 15+	4.05	3.98	3.91

Table 10 – Tax shocks on tobacco products

A -15% decrease in the total quantity of tobacco consumed requires a tax shock of about +110%, *i.e.* for the pack of the most consumed brand of cigarettes, a price shift from 5€ to more than 7€ ; following such a shock, tax receipts increase by nearly 60%, generating a fiscal gain for the government of more than €3.5 billion; the average number of cigarettes consumed daily per person 15+ goes from 4.13 to 3.5 corresponding to a reduction of a dozen packs of cigarettes per year.

As for alcohol, and except if the government is ready to implement extremely high tax rises, it seems that the tax policy can with difficulty be the only instrument in the fight against smoking and that several tools must be manipulated simultaneously to achieve a substantial reduction in tobacco consumption.

SIMULATIONS – TOBACCO CONSUMPTION TARGETS	Decrease -5%	Decrease -10%	Decrease -15%
Required increase in tax on tobacco	+30%	+65%	+110%
BEFORE SHOCK			
Price of a normalized pack of cigarettes (€)		3.46	
Price of a pack of cigarettes of the most consumed brand (€)		5.00	
Population 15 and over (millions)		49.663	
Tobacco spending (millions €)		12 951	
Tax receipts (millions €)		6 110	
Total tobacco consumption (millions of packs of cigarettes)		3 739	
Grams of tobacco per year/person 15+		1 205	
Cigarettes per day/person 15+		4.13	
AFTER THE SHOCK AND WITHOUT BEHAVIOR ADJUSTMENT (*i.e.* price effect only)			
Price of a normalized pack of cigarettes	3.84	4.29	4.87
Variation in %	10.99%	23.94%	40.51%
Variation in €	0.38	0.83	1.40
Price of a pack of cigarettes of the most consumed brand (€)	5.55	6.20	7.03
Variation in €	0.55	1.20	2.03
Tobacco spending (millions €)	14 374	16 051	18 198
Tax receipts (millions €)	7 534	9 211	11 357
Variation in %	23.30%	50.74%	85.86%
Variation in millions €	1 424	3 100	5 247
AFTER THE SHOCK WITH BEHAVIOR ADJUSTMENT (price and quantity effects)			
Tobacco spending (millions €)	13 631	14 433	15 459
Variation in %	5.25%	11.44%	19.36%
Tax receipts (millions €)	7 144	8 282	9 648
Variation in %	16.92%	35.54%	57.89%
Variation in millions €	1 034	2 172	3 537
Total tobacco consumption (millions of packs of cigarettes)	3 545	3 362	3 176
Variation in %	-5.00%	-10.00%	-15.00%
Grams of tobacco per year/person 15+	1 142	1 083	1 023
Cigarettes per day/person 15+	3.91	3.71	3.50

Table 11 – Tax shocks required to reach different targets of tobacco consumption

5. - Evaluation of the impact of taxation on mortality

The purpose of this section is to evaluate the consequences in terms of reduced mortality of the different tax shocks simulated in the previous sections. To compute the "monetary gains" associated with any particular level of mortality reduction, we have used the value of human life - 1,5 millions euros - proposed in Boiteux M. & Baumstark L. [2001] which is often used for cost/benefit evaluations of French public policies ; taking into account the evolution of the general price index between 2001 and 2004, the value of human life can be estimated at 1.65 million euros in 2004. The discount rate used to compute the discounted value of monetary gains associated with the different tax policies has been set to 6%.

Alcohol

In France, 23000 deaths are directly imputable to alcohol each year, 18388 men, and 4722 women. [9] More specifically we have each year in France:

- 11706 deaths from cancers (of which 5003 lip cancers, buccal cavity or pharynx, 4432 esophagus cancers and 2271 larynx cancers) ;
- 8863 deaths from cirrhosis;
- 2541 death from alcohol dependency.

Besides deaths which are directly attributable to it, alcohol is an associated factor in numerous other illnesses; globally one estimates at 45000 the number of deaths, directly or indirectly, imputable to alcohol in 1995 (*cf.* Table below; source Hill C. [2000]).

	Cancers	Mental illness	Cardio-vascular	Respiratory	Digestive	Accidents and poisoning	Unspecified	Total
Men	14 000	2 000	7 000	1 000	6 000	6 000	2 000	38 000
Women	2 000	500	600	100	2 200	1 100	500	7 000

Number of deaths attributed to alcohol for the main alcohol related illnesses

For estimates presented in table 12 we used the following hypotheses:

- Stability, since 1995, in the number of direct and indirect deaths linked to alcohol abuse;
- Elasticity of mortality linked *directly* to alcohol, to the annual consumption of pure alcohol, equal to unity : x% decrease in the annual consumption of pure alcohol = x% decrease in the direct mortality
- Elasticity of mortality linked *indirectly* to alcohol, to the annual consumption of pure alcohol, equal to 1/3 : x% decrease in the annual consumption of pure alcohol = 1/3x% decrease in the indirect mortality

To give an example, under the above set of hypotheses, a 10% increase of alcohol excise duties, induces a limited 1,26% reduction (see table 8) of annual pure alcohol consumption, which prevents around 384 deaths per year, corresponding to an annual gain of 630 million euros and a discounted return of 11 billions euros.

[9] Expertise collective Inserm 2001, data 1998

To summarize the main economic lessons drawn from the simulations, we can retain as an approximation that – for moderate increases in excise duties – a *x*% tax increase allows saving 40 time *x* lives, corresponding to a discounted benefit of *x* billions euros.

HYPOTHESES			
Value of human life (millions €)	1,65		
Discount rate	6%		
Number of deaths per year for which alcohol is directly responsible	23000		
Number of deaths per year for which alcohol is indirectly responsible	22000		
SIMULATIONS –ALCOHOL TAX SHOCKS	**Increase 10%**	**Increase 20%**	**Increase 30%**
Results in terms of mortality			
Number of deaths avoided per year	384	760	1 109
Results in monetary terms (euros)			
Annual gain (billions €)	0,63	1,25	1,83
Present discounted value of the gain (billions €)	11	21	30
SIMULATIONS – CONSUMPTION TARGETS	**Decrease 5%**	**Decrease 10%**	**Decrease 15%**
Necessary increase in taxes on alcohol (recall)	45%	90%	160%
Results in terms of mortality			
Number of deaths avoided per year	1 618	2 935	4 561
Results in monetary terms (euros)			
Annual gain (billions €)	2,67	4,84	7,53
Present discounted value of the gain (billions €)	44	81	125

Table 12 –Tax shocks on alcohol, mortality and monetary returns

Tobacco

The total number of regular smokers in France has been estimated at around 12.67 millions in 2003 (Hill C. & Laplanche A. [2005]), corresponding to 30% of the male population and 22% of the female population. The percentage of these smokers whose death is directly linked to their tobacco consumption has been evaluated by Chaloupka and *alii* [2000] at a little more than one third, or 34,27%, which corresponds to about 67000 deaths per year.

Evaluating the mortality decrease associated with different tax shocks implies taking into account the two dimensional impact of an increase in tobacco price on total cigarette consumption. Understanding this two dimensional impact is quite straightforward if one notes that the reduction of tobacco consumption is in fact the product of two different phenomena characterized by very different implications in terms of mortality: faced with an increase in tobacco price some smokers reduce their consumption while others just stop smoking.

On this particular point, we have used the method proposed by Chaloupka and *alii* [2000] who feel that 50% of the price-effect affects the prevalence; the variation in the number of smokers after a price shock – *i.e.* the number of smokers who stop smoking – is then considered as the product of:

- The price elasticity
- The percentage of cigarette price variation
- The impact of 50% on prevalence
- The total number of smokers

The number of premature deaths avoided by the decrease in the number of smokers is then evaluated, according to the method proposed by Chaloupka and *alii* [2000] as the product of:

- The number of prior smokers having stopped smoking following the price shock
- The proportion of smokers who die from tobacco use
- An adjustment factor – estimated at 0,75 by Chaloupka and *alii* [2000] – translating the fact that, on average, 25% of prior smokers die, *despite having stopped*, from illnesses linked directly to their past use of tobacco.

The number of deaths avoided yearly is eventually obtained by dividing the total number of premature deaths avoided, by the number of years over which these deaths would have been spread *i.e.* about 65 years.

It should be pointed out here that this method, taken from Chaloupka and *alii* [2000], implicitly assumes that reduced cigarette consumption of those who decide to continue smoking, has no bearing on mortality; this hypothesis should logically lead to an underestimation of the impact of the tax shock on the decrease in mortality, so that our estimates are probably "conservative".

Evaluation of the total number of years of life saved, is based on the work of Doll R and *alii* [2004], who estimate at around 6.5 years the average gain in life expectancy of a smoker who quit smoking; we thus evaluate the total number of years of life saved, by multiplying by 6.5 the number of smokers having stopped following a tax shock. Eventually, dividing the total number of years of life saved, by the life expectancy, gives an estimation of the number of "entire" lives saved.

The conversion into monetary gain uses the same set of hypotheses as we previously used for alcohol. In this section we propose however two different methods to compute the monetary gain. The first method consists in first estimating the "value" of the number of deaths avoided yearly (by multiplying the total number of deaths avoided yearly by the value of human life) and then calculating the associated present discounted value with a 6% discount rate. The second method provides an estimation of the monetary returns by simply multiplying the total number of "entire" lives saved, by the value of human life.

Reading of Table 13 shows that a 10% increase on tobacco taxes avoids 455 deaths per year, corresponding to a present discounted return for the French economy standing between 12 and 15 billions euros, while a 30% increase multiplies by three these different values, saving a little more than two million years of life for a limited increase of 55 cents on the pack of cigarettes the most frequently sold. (*cf.* Table 10).

Symmetrically, a 10% decrease in tobacco consumption, obtained by an increase of 65% in the tax on tobacco products, raising the price of the average pack of cigarettes to 6,20 € (*cf.* Table 11), creates an incentive to quit for 638 000 smokers, avoiding around 164 000 premature deaths *i.e.* more than 2500 deaths per year on average. In such a situation, the corresponding gain for the French economy lies between 70 and 80 billions euros.

HYPOTHESES			
Value of human life (millions €)	1,65		
Discount rate	6%		
Number of regular smokers (millions)	12,67		
Number of smokers dying from tobacco use	34,27%		
Number of deaths per year	66 805		
SIMULATIONS –TOBACCO TAX SHOCKS	**Increase 10%**	**Increase 20%**	**Increase 30%**
Results in terms of mortality			
Smokers quitting	114 934	225 778	327 487
Variation in %	-0,91%	-1,78%	-2,58%
Premature deaths avoided	29 543	58 035	84 179
Number of deaths avoided per year	455	893	1 295
Estimate of the total number of years of life saved (millions)	0,747	1,468	2,129
Equivalent number of entire lives saved	9 280	18 231	26 443
Conversion in monetary terms (billions €)			
Method n°1			
Annual benefit	0,75	1,47	2,14
Present discounted value of the gain	12	25	36
Method n°2			
Gain corresponding to the number of entire lives saved	15	30	44
SIMULATIONS – CONSUMPTION TARGETS	**Decrease 5%**	**Decrease 10%**	**Decrease 15%**
Necessary increase in tax on tobacco (recall)	30%	65%	110%
Results in terms of mortality			
Smokers quitting	327 487	638 721	953 422
Variation in %	-2,58%	-5,04%	-7,53%
Premature deaths avoided	84 179	164 180	245 073
Number of deaths avoided per year	1 295	2 526	3 770
Estimate of the total number of years of life saved (millions)	2,129	4,152	6,197
Equivalent number of entire lives saved	26 443	51 574	76 984
Conversion in monetary terms (billions €)			
Method n°1			
Annual benefit	2,14	4,17	6,22
Present discounted value of the gain	36	69	104
Method n°2			
Gain corresponding to the number of entire lives saved	44	85	127

Table 13 –Tax shocks on tobacco, mortality and monetary returns

It is interesting to put these results into perspective with the hundred objectives annexed to the French Public Health Law of August 9, 2004 ; concerning tobacco the target announced is "*to lower the prevalence of tobacco use (daily smokers) from 33 to 25% for men, and from 26 to 20% for women, by 2008 (targeting particularly young people and those social categories having high prevalence*)" ; roughly speaking such a target means reducing by about 25% the number of smokers between 2004 and 2008.

Analysis of results summarized in Table 13, highlights – as for alcohol – the ambitiousness of the public authorities' targets. According to our computations, an increase of 110% in tax on tobacco – corresponding to a price increase greater than two euros for a pack of cigarettes of the most consumed brand – implies a decrease limited to about 7.50% in the total number of

smokers[10]. It is clear then, even more than for alcohol, that the announced public health objectives cannot be achieved by using only the tax policy tool, unless the government is ready to accept a very huge increase in the price of the pack of cigarettes.

6. - Conclusion

The purpose of the paper was to measure the impact of increasing alcohol and tobacco taxes, on the consumption of these products and the induced mortality, using a microsimulation model of French household spending.

The results show that a 10% increase in specific taxes on alcoholic products induces a decrease in mortality equivalent to a monetary discounted return standing around 10 billions euros; comparing with alcohol, the "efficiency" of increasing taxes on tobacco products is 50% higher: a 10% increase of specific tobacco taxes induces a decrease in mortality equivalent to a monetary discounted return standing around 15 billions euros. In terms of mortality, one can retain as an approximation that – for moderate increases in excise duties – a 10% tax increase on alcohol *vs* tobacco products allows saving about 380 *vs* 450 lives each year.

From a public policy point of view, our estimations highlight the ambitiousness of the public authorities' health targets concerning tobacco consumption as they appear in the hundred objectives annexed to the French Public Health Law of August 9, 2004; it is clear from our simulations, that the announced public health target of a -25% decrease of the number of smokers in four years, cannot be achieved by using only the tax policy tool.

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[10] The total number of daily smokers would nevertheless decrease more than 950 000, avoiding 250 000 premature deaths and inducing a monetary benefit greater than 100 billions euros for the French economy.