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Why would upward trends in schooling make a nation healthier? The case of smoking in Twentieth Century France

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WHY WOULD UPWARD TRENDS IN SCHOOLING MAKE A NATION HEALTHIER? THE CASE OF SMOKING IN TWENTIETH CENTURY FRANCE.*

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Abstract

Taking smoking as an example, this paper asks whether relative levels of education matter as much as absolute levels in explaining the education-health gradient. We show that relative education impacts smoking, when direct utility is relative, or when there is signalling in the labour market. We use data from the "Enquête sur les Conditions de Vie des Ménages 2001" and a major reform of the education system, the Haby reform, to test the competing hypotheses. Descriptive statistics show that education has more effect on the decisions to start and quit for the birth cohorts affected by the reform. However, duration analysis reveals that, controlling for changes in policies, this result holds only for quitting.

JEL Codes:C33, D83, I12,I18.

Keywords: Smoking, Schooling, .

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1 Introduction

The relationship between education and health has been widely investigated since Grossman's seminal work on the demand for health. Since all the evidence points to a positive correlation between education and health, one method of improving population health would be to increase the population level of education (Grossman, 2000). In this perspective, Deaton (2002) argues that health policies pay too much attention to health-care and health-related behaviours and should refocus toward education and income. Raising the education level of the population, through for instance public subsidies to schooling, should make the nation healthier. Yet, the education-health gradient still persists in developed countries, while the population educational attainments increased massively throughout the Twentieth Century and information about the health effects of a number of behaviours became widespread. This reflection is especially relevant for smoking (Fuchs, 2004).[1] Deaton also remarks that the persistence of the gradient may be consistent with the view that it is not education or income itself that matters, but social status. Taking the case of cigarette consumption in Twentieth Century France as an example, this paper asks whether the relative level of education (as an indicator of social status) matters as much as the absolute level of education for explaining the education-health gradient. We use French individual data on smoking histories from the survey "Enquête sur les Conditions de Vie des Ménages 2001" (INSEE) to address this question.[2]

In this paper, education is not measured by formal years of schooling but by the highest education level achieved by the individual. Relative education is thought of as the position one can expect to attain with a given education level in the distribution of education levels of one's birth cohort. There are two routes through which education may affect smoking. First, the more educated are more capable to process and to use health information. They have a comparative advantage in producing health: this is the efficiency hypothesis. Second, the more educated have higher returns to health investment, because they face higher losses from dying prematurely: this is the opportunity cost explanation. Using a simple model, we show that relative education impacts smoking, when direct utility is relative, or when there is signalling in the labour market. In both cases, indirect utility depends on relative education, so that the latter affects positively the opportunity cost of smoking. Relative education may also be correlated with efficiency in health production, if one is willing to assume that it is a signal for cognitive ability and that cognitive ability has a direct impact on smoking.

Since the absolute and the relative education levels are collinear, identifying the effect of relative education on smoking requires that a shock on relative education, holding the absolute level of education constant, be observed. This paper identifies the effect of relative education by using a major reform of the French educational system that occurred in 1976, the Haby reform, which induced large changes in the distribution of education levels for individuals born after 1965, by lowering the selection hurdles at various stages of the education system (Magnac and Thesmar, 2002). After the Haby reform, the social position secured by almost all qualifications was lower, except of course for the top degrees. Descriptive statistics on smoking participation (starts and quits) show that the education-smoking gradient was stronger for the birth cohorts that were affected by the Haby reform. This provides some supports in favour of the relative education argument. However, the birth cohorts we observe faced different smoking policies, which could bias these difference-in-difference results. To control for changes in smoking policies, we apply duration models to the decision of starting and quitting smoking. The idea is to construct a pseudo-panel by expanding the data set over calendar years, and couple this information with time series variations in prices. Prices can then be treated as time-varying covariates. As price variations in France are determined at a national level and have been coordinated with information campaigns since their very beginning in 1976, this estimation strategy helps us to control for changes in smoking policies. In this multivariate regression setting, we find that the education gradient is effectively stronger for the cohorts that were affected by the Haby's reform, but for the decision to quit smoking only.

The duration models we use deal with any unobserved heterogeneity (and thus omitted variable) that is uncorrelated with education. However, as Farrell and Fuchs (1982) point out, a third unobserved factor, for instance preference for the present or cognitive ability, may explain the negative correlation between smoking and education. While the empirical literature has provided little evidence in favour of the "discount factor" bias, it has been found that unobserved cognitive abilities may increase the education-health gradient, at least in the upper part of the education distribution (Grossman, 2004, Auld and Sidhu, 2005). One may also argue that lowering the selection hurdles in the education system would mean that the human capital associated with a given education level is lower for the younger cohorts. These arguments may explain why the education-smoking gradient is now stronger than it was. However, we reject them in the discussion section.

Last, while the efficiency argument predicts that the effect of information policies should steadily increase with the education level, we do not find such a clear gradient. The results draw however a clear distinction between those individuals with post-Baccalaureat degrees and the others. This yields some support to the opportunity costs explanation of the education-smoking gradient, since the returns to the Baccalaureat and qualifications below the Baccalaureat tended to converge over the past 30 years. In conclusion, the education-smoking gradient persists because the well-being associated to a given education level depends on the social position this education level helps to secure. This finding has consequences for public health policies.

The remainder of this paper is organized as follows. Section 2 outlines the possible links between education and smoking, and formulates a theoretical model that shows how relative education may affect smoking. Section 3 presents the data, and describes the reforms of the educational system and the changes in tobacco policy over the twentieth century in France. Section 4 presents the statistical models. The main results are displayed in Section 5. Our main findings are discussed in Section 6. Section 7 concludes.

2 Why would the more educated smoke less?

2.1 Education, efficiency and the opportunity costs of smoking.

Education enhances capabilities to process new information about the risks of smoking-induced health events. This is the efficiency argument developed by human capital economists (Grossman, 2000). Differences in abilities to use information affect selection into smoking, and changes in these abilities at the population-level should have had a clear impact on the social mix of smokers. Indeed, smoking is now more widespread among the poorer and less educated than the richer and more educated in Western countries (see Aliaga, 2001, for France). However, upward trends in education and the rise of the mass media era weaken this explanation. In France, recent population surveys show that almost 90% of the population and 85% of smokers recognize that smoking is addictive and harmful (HCSP, 1998). Even if knowledge about the health risks of smoking is incomplete, less educated individuals understand the major dangers from smoking, so that the scope for diffusion of information about the health consequences of smoking is now limited (Kenkel, 1991, Viscusi, 1992, Sloan *et al.*, 2003).[3]

Smoking does not only depend on the probability of an adverse health event, but also on the incurred losses which depend on education through the discounted wage stream one can expect to receive over one's lifecycle. Since the more educated individuals have higher wages, they face *ceteris paribus* higher potential losses: education is positively correlated with the opportunity cost of smoking. In France, the monetary costs of smoking have increased for all education levels since World War II, as a consequence of economic growth and the development of welfare policies. But a recent study has found that, between 1980 and 2000, tobacco expenditures of French households in the three lowest deciles of the income distribution did not react to price increases, while the expenditures of the richest households strongly decreased (Godefroy, 2003).

Given that the link between the *position* in the income distribution and smoking seems to matter and that the efficiency argument is of little relevancy, one may wonder whether relative education is not as important as the absolute level of education for explaining the education-smoking gradient. In this perspective, the present paper examines the connection between the position in the distribution of qualifications, *i.e.* relative education, and smoking. The intuition is that the future well-being expected from a given qualification changes over time, and is likely to be lower for younger cohorts as a consequence of the overall rise in education levels. Hence, changes in the relative values of education levels may induce variations in the education-related opportunity costs on smoking. The rest of this section formalises this argument.

2.2 A model of education and smoking

We consider a consumer in a two-period, two-goods economy. To keep things simple, there is no saving. Let c_t and y_t be respectively the consumption of tobacco and a numeraire good over period *t*, and suppose that direct utility is relative, in the sense that comparisons affect utility: utility is positively correlated with social status (Duesenberry, 1949, Clark and Oswald, 1996, Ferrer-i-Carbonell, 2005). The utility function of the consumers is $U(c_t, y_t; S)=u(c_t)+ y_t v(S)$, where *S* is a social status indicator, u(.) is an increasing concave function and v(.) is an increasing function. Let *E* be the education level of the consumer. As education and other social status indicators (income, job, housing etc.) are positively correlated, we assume that S is a variable that measures relative education. In this paper, relative education is the position in the distribution of education levels of the birth cohort. At each period, the consumer earns a wage which depends on both E and S, w(E,S), because signalling may play as important a role on the labour market as human capital (Spence, 1973). Hence, wage increases in both E and S: $w_E \geq 0$ and $w_S \geq 0$. The budget constraint is $w(E,S)=y_t-pc_t$, where p is the relative price of cigarettes.

We also introduce a survival probability for the second period, $\pi(c_1,K)$, which depends on the first-period tobacco consumption and knowledge K. We assume that $\pi(.)$ is decreasing and concave in c and decreases in K, and that $\pi(0,K)=1$. To capture the efficiency hypothesis, we suppose first that those who have more knowledge perceive higher marginal risk from smoking, so that the cross-derivative π_{cK} is negative. Second, knowledge K is produced using education and a set of information Ω, such that the more educated are more efficient: K=h(E, Ω) with h_E, h_Ω, $h_{E\Omega} \geq 0$ and h_{EE}, $h_{\Omega\Omega} \leq 0$. Ignoring corner solutions, the maximisation problem is:

$$\begin{aligned}&\mathrm{Max}_{c_1, c_2, y_1, y_2} \left\{ u(c_1) + y_1 v(S) + \beta(E)\pi(c_1, K)\left[u(c_2) + y_2 v(S)\right]\right\} \\ &w(E, E^*) = y_t + pc_t, t = 1, 2\end{aligned} \quad \textbf{(1)}$$

where β is a discount factor, which is non-decreasing in E (Becker and Mulligan, 1997). Since there is no saving, the optimal solution can be found by solving the optimisation problem for the second period only. Denote by V(E,S) the second-period indirect utility function, we have:

$$\begin{aligned}&V(E, S) = \mathrm{Max}_{c_2, y_2} \left\{ u(c_2) + y_2 v(S) \right\} \\ &w(E, S) = y_2 + pc_2\end{aligned} \quad \textbf{(2)}$$

Using the envelope theorem, the effects of the education level E (S being held constant) and the relative education S (E being held constant) on the second period well-being are:

$$\begin{aligned}&V_E = w_E v(S) \geq 0 \\ &V_S = w_S v(S) + \left[w(E, S) - pc_2\right] v'(S) \geq 0\end{aligned} \quad \textbf{(3)}$$

The first-order condition of **(1)** with respect to c_1 reveals the opportunity costs of smoking:

$$u_c(c_1) = pv(S) - \beta(E)\pi_c(c_1, K)V(E, S) \quad \textbf{(4)}$$

Equation **(4)** shows that the full price of smoking is the sum of its market price, pv(S), and the expected marginal cost of smoking, $-\beta\pi_c V(E,S)$, which is positive since π_c is negative. The second-period indirect utility, V(E,S), as well as the subjective value of foregone consumption pv(S), represent the education-related opportunity cost of smoking.

2.3 The effect of education on smoking

Why is there a smoking-education gradient in any given birth cohort? Consider an exogenous shock on E. It has a direct effect, and an indirect effect which works through a change in relative education S. By differentiating equation **(4)** we obtain:

$$\frac{dc_1}{dE} = \underbrace{\frac{-\beta'\pi_c V - \beta\pi_{cK} h_E V - \beta\pi_c V_E}{u_{cc} + \beta\pi_{cc} V_E}}_{\text{direct effect}} + \underbrace{\frac{pv'(S) - \beta\pi_c V_S}{u_{cc} + \beta\pi_{cc} V_E}\frac{dS}{dE}}_{\text{indirect effect}} \qquad \textbf{(5)}$$

Given the signs of the derivatives in the right hand side, a positive shock on E has a negative effect on consumption. This result holds first because indirect utility is relative (v' ≥ 0 and $V_S \geq 0$) and relative education increases with education in the birth cohort (dS/dE ≥ 0). Hence, the value of foregone consumption is higher for the more educated, as well as the marginal losses of utility if they do not survive in the first period. The latter is true even when indirect utility is not relative: the more educated face anyway higher education-related opportunity costs because their productivity is higher (V_E>0). Moreover, the more educated are also more efficient ($h_E \geq 0$ and $\pi_{cK} \leq 0$) so that they perceive an higher marginal risk of not receiving the second period benefit V. Last, the positive effect of education on the discount factor (β ≥ 0) reinforces the gradient. Hence, we should observe a negative smoking-education gradient in any birth cohort. This is the first prediction of the model.

Now, compare two individuals with the same education level E, but belonging to two different birth cohorts, so that their relative education level S is not the same. When indirect utility is relative, an exogenous shock on S (E being held constant) has a negative effect on smoking. Indeed, equation **(4)** implies that:

$$\frac{dc_1}{dS} = \frac{pv'(S) - \beta\pi_c V_S}{u_{cc} + \beta\pi_{cc} V_E} \qquad \textbf{(6)}$$

Equation **(6)** tells us that smoking decreases with relative education. This result holds only because there is signalling and/or utility is relative, and does not rely on the efficiency argument but only the opportunity cost argument. Hence, a second prediction of the model is that the education-smoking gradient should be steeper when the relative education associated with any given education level is lower. The next section presents the data and explains how comparing smoking behaviours between birth cohorts helps to test the model's predictions.

3 Data

This paper studies smoking behaviour through the decisions to start and quit smoking. Retrospective data on smoking histories were drawn from the "Permanent Survey on the Conditions of Living of French Households" (hereafter **EPCV2001**). This is a nationally representative survey of roughly 5,200 households conducted by the French national institute for statistics and economic studies (INSEE). A core section gives detailed information on individual characteristics. Of the 12,653 individuals surveyed, one member of each household was randomly drawn to answer a special health section. There are a total of 5,194 observations for which socio demographic and health variables are available.

3.1 Sample selection and measures of smoking

A smoker or a former smoker is defined as someone who smokes or used to smoke at least one cigarette a day. Figure 1 below reports the prevalence of lifetime smoking by year of birth for all individuals surveyed in EPCV2001 and born after 1910 (grey bars). Ignoring those born in the first years of the last century (before 1910), the proportion of lifetime smokers is concave in the year of birth, with a maximum for the cohorts born around 1970. This may reflect a mortality bias: lifetime smokers are less likely to be represented in older cohorts, since they die earlier. The mortality bias may have important consequences for the estimation of education and price effects, because the elderly surveyed in 2001 are, on average, less educated and less prone to have started smoking. Such bias can go either way, depending on whether smokers' mortality risk increases or not with education.[4] A well-known epidemiological study of male British doctors monitored over 50 years shows that survival probabilities of smokers and non-smokers begin to diverge around age 50 (Doll *et al.*, 2004). For this reason, we work with a sample restricted to individuals born after 1948, *i.e.* aged under 53 in 2001. This selection rule was also chosen because we have quite homogenous INSEE price series for the period 1949-2001. We also consider that starts before age 11 or after age 30 represent outliers, and drop the corresponding observations. Last, we only keep individuals who were no longer studying in 2001 to avoid measurement errors on education. This sample selection procedure leaves us with 2589 individuals for whom lifetime smoking prevalence by year of birth is represented by the black bars in Figure 1.

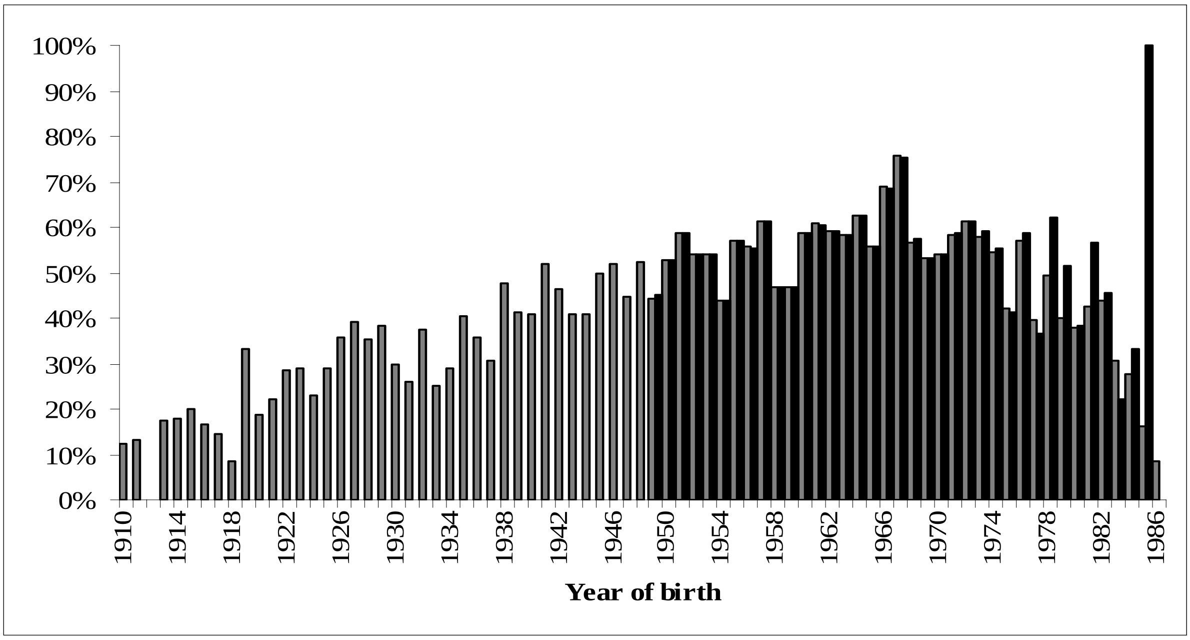
Starting smoking

For those individuals who have smoked at some point in their lives, we analyse the decision to start smoking by using answers to the following question: "How old were you when you (first) started to smoke regularly?". This defines the dependent variable: the starting age *T*. An important feature of the data set is that many individuals have not started smoking at the time of the survey. For them, *T* is their age at the time of the survey. These observations are interpreted as right-censored spells in standard duration analysis. Here we relax this assumption by using a split-population model.

Quitting smoking

To analyse the decision to quit smoking, we use the sub-sample of smokers and former smokers for whom we know the time since the most recent quit ("How long ago did you quit smoking?", N=1444). Hence, the dependent variable is smoking duration, which is computed as the date at the time of the survey minus the date of starting minus, for former smokers only, the time since quitting. Occasional smokers at the time of the survey (less than one cigarette a day) who used to smoke daily at some point of their life are considered as former smokers.

Figure 1. Sample proportion of lifetime smokers by year of birth in EPCV2001.



3.2 Education and smoking

We have several reasons for considering that years of schooling are not an appropriate indicator of health knowledge. First, as stated by Chevalier et al. (2004), "knowledge may […] come in indivisible "lumps" and it make sense for these to be associated with credentials". Second, teens who do not perform well enough in the first cycle of Secondary School, are oriented into vocational tracks. The type of educational track individuals are engaged in is thus a better measure of abilities to understand health warnings than formal years of schooling. Given the historical changes in the nomenclature of degrees, we used seven education levels to measure the highest national degree achieved by the individual, and eventually grouped them into four levels: no qualification and primary education (*NOQUAL / CEP*), short secondary general and vocational/technical or professional education under the Baccalaureat (*BEPC / CAP*), the Baccalaureat (*Bac*), degrees after the Baccalaureat (*Bac 2 / Bac3+*). Table A1 in Appendix A defines these education levels and gives some equivalence between French, UK and US educational programmes according to the ISCED-97 classification (OECD, 1999).

Figures A1 and A2 in Appendix A show how the distribution of education levels evolved for the birth cohorts born after 1949. There has been a clear rise in education levels for both women and men throughout the second part of the century. Needs for skilled workers strongly increased after World War II as well as the demand for education so that, in 1959, the Berthoin reform of the educational system was designed to favour the access of all social classes' children to secondary education.[5] A second hurdle toward mass education was crossed with the Haby law, adopted in 1976, which has unified the educational tracks for the first cycle of the secondary schools for individuals born after 1965. Before this law, pupils could be oriented into vocational tracks after the second (completed) year of Secondary School, while orientation is now usually determined after four years (Prost, 1981). In 1984, the Ministry of Education decided 80% of each cohort should achieve the Baccalaureat level, and a new "vocational" Baccalaureat was created in 1985/1986. Nowadays, about 60% of individuals born at the end of the 1970's have the Baccalaureat, whilst this figure was only 20% for those born in the 1950's.

Table 1 shows some descriptive statistics about the education-smoking relationship. For each gender and education level, this table contrasts the lifetime smoking prevalence, mean age of starting of the starters, and the mean smoking duration for two cohorts: on the one hand the individuals born before 1966 and, on the other hand, those born after 1965, whose schooling decisions were affected by the Haby reform. The odds ratios give, for education level and gender, the relative risk of being a lifetime smoker or of having quit smoking, the category of reference being respectively Bac2 / Bac3+ and women.

Decomposition of smoking behaviour by education levels reveals some changes between the birth cohorts. A powerful association between education and smoking initiation is apparent but for those individuals born after 1965 only, as shown by the trends in odds ratio. Hence, the education-initiation gradient is stronger in the cohorts affected by the Haby reform. The comparison of the birth cohorts indicates that there has been a slight decline of the risk of initiation amongst the more educated, while this risk strongly increased amongst the less educated. The education-quits gradient becomes steeper in the youngest cohort, but smoking duration (i.e. addiction) is an important confounding factor here. We also observe changes in gender effects. For instance, as in the US or the UK, the risk of initiation increased for women (Douglas and Hariharan, 1994, Forster and Jones, 2001). Despite smoking policies, this risk is now closer to that of men.

Figures A3 to A6 in Appendix A show non-parametric estimates for the hazard of starting smoking and the hazard of smoking duration by education levels, gender and cohorts. These non-parametric regression results draw a picture consistent with our previous finding on the strengthening of the education gradient, since the gap between the less and the more educated is clearly higher in the post-Haby reform cohort. One also observes that the gender gap has been partially closed, since, whatever the education level, younger females have a higher propensity to start at every age. This propensity remained fairly stable for the less educated males and dropped for the more educated males. The latter have also a higher hazard of quitting for all smoking durations, while this is not true for the former.

Table 1. Smoking behaviour by education level and cohort

Starts				
Born before 1966				
	N	% lifetime smoker	Odds ratio: lifetime smoking	Average starting age if lifetime smoker
NOQUAL / CEP	352	55.7	1.309*	17.41
BEPC / CAP	609	58.1	1.447***	17.64
Bac	185	54.1	1.226	17.87
Bac2 / Bac3+	339	49.0	reference	19.23
Men	689	66.2	2.370***	17.57
Women	796	45.2	Reference	18.4
Born 1966 and after				
NOQUAL / CEP	153	68.6	2.408***	16.35
BEPC / CAP	393	62.1	1.802***	16.51
Bac	203	54.2	1.302	17.31
Bac2 / Bac3+	355	47.6	reference	17.72
Men	513	58.1	1.096	16.95
Women	591	55.9	reference	16.95

Quits				
Born before 1966				
	N lifetime smoker	% quitter	Odds ratio: quits	Average smoking duration if quitter
NOQUAL / CEP	196	36.2	0.905	15.66
BEPC / CAP	354	37.6	0.959	15.84
Bac	100	50.0	1.594*	15.12
Bac2 / Bac3+	166	38.6	reference	14.14
Men	456	40.1	1.117	17.17
Women	360	37.5	reference	12.87
Born 1966 and after				
NOQUAL / CEP	105	12.4	0.263***	8.69
BEPC / CAP	244	22.1	0.530***	9.07
Bac	110	26.4	0.668	8.55
Bac2 / Bac3+	169	34.9	reference	8.24
Men	298	18.8	0.540***	8.95
Women	330	30.0	reference	8.05

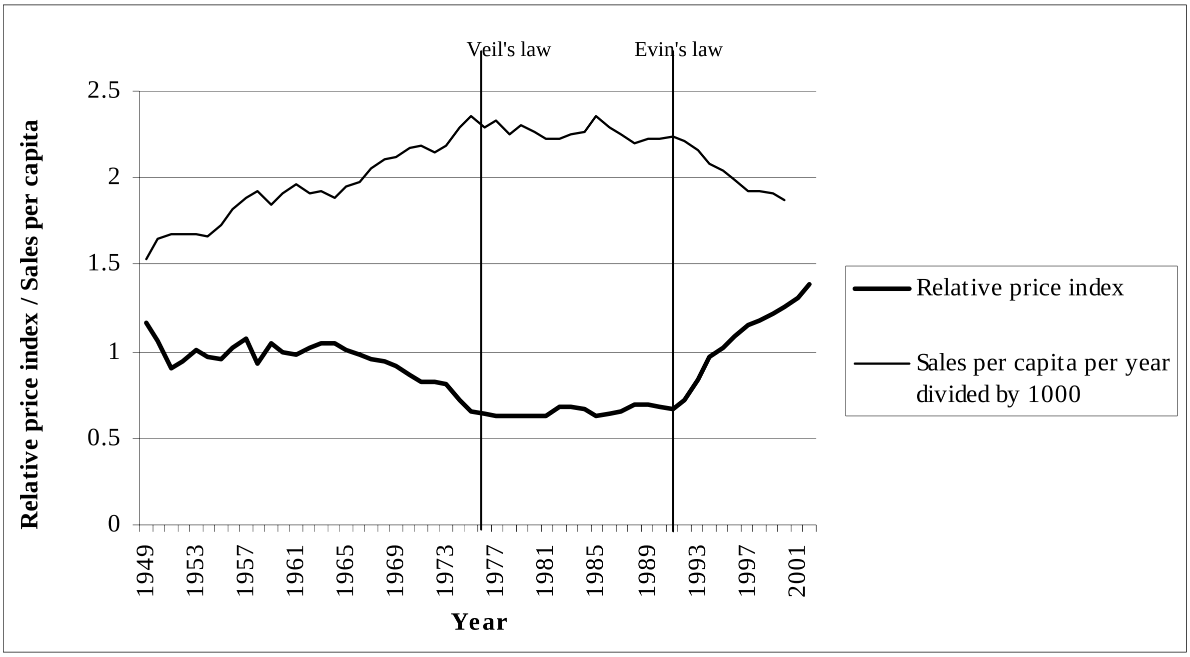
Note : * odds ratio different from 1 at the 10% level; ** at the 5% level; *** at the 1% level.

From these descriptive statistics, it becomes clear that a simple way to test the model's predictions about the role of relative education is to introduce interactions between cohorts and qualifications in multivariate regressions. However, we also have to control for differences in exposures to smoking policies, which may explain cross-cohort variations.

3.3 Price and smoking policies.

Selling and even producing tobacco has long been a state-monopoly in France, except between 1717 and 1789 when the monopoly was conceded to the colonial estate "Compagnie des Indes". Until the beginning of the 1970s, tobacco-related illness was not a pressing concern for health authorities in France, albeit the first custom tax on tobacco products was set-up by King Louis XIII in 1629 on the "official" ground that tobacco affected health (Nourrisson, 1999). Since 1674 French governments have considered the monopoly as a secure source of tax revenues and relied on tobacco excise taxes to support the public finances. Even though the first report on nicotine toxicity date back to Dr. Bailly's experiments with dogs in 1693 and that the first anti-smoking league was set up in 1877, laws to ban smoking in public places and pro-smoking advertising, and to set up prevention policies were adopted much later on, in 1976 (Veil's law) and 1991 (Evin's law) (Dubois, 2003). To examine trends in sales and price over the 20th century, yearly sales data were obtained from the tobacco industry documentation centre (Centre de Documentation et d'Information sur le Tabac). We aggregated cigarette and loose tobacco (for hand-made cigarettes, pipes and chewing) sales, with a conversion rate of 1g per cigarette.[6] A relative price index was constructed using INSEE data for the period (1949-2002). Figure 2 below shows that yearly sales per capita continuously increased from 1949 until the Veil law, with a parallel drop in prices. Then the prices did not move for almost 15 years, as well as the consumption. From the early 1990s, there has been a strong price increase. Indeed, Evin's law allowed the Government to remove tobacco prices from the computation of the Consumer Price Index used in the perspective of the European monetary union. Then, strong tax increases were coupled with even more vigorous information-based anti-smoking campaigns.

Figure 2. Secular Trends in Price & Sales



In France, information and pricing policies are highly collinear, as a consequence of the State control over the market. Hence, from a statistical point of view, price changes carry information about the risks of smoking, especially since 1976 when tax increases began to be systematically coupled with mass media information campaigns. As part of the average price effect may actually reflect an information effect, and exposure to public information may vary with education, we will interact prices and education levels.

4 Statistical methods

4.1 Specification

Identifying the effect of relative education on smoking requires that the effect of a change in *S* be controlled, given that *S* can not be directly observed. We postulate that the Haby reform decreased the social status associated to many qualifications for individuals born after 1965. This assumption is supported by research that emphasizes the rise over the last 30 years in the returns to degrees under the Baccalaureat, the decline of the returns to the Baccalaureat and the stability of the returns to post-Baccalaureat degrees (see, *inter alia*, Goux and Maurin, 1994, Magnac and Thesmar, 2002, Selz and Thelot, 2004). Hence, a natural way to proceed is to include in the specification of the statistical model an interaction between the education level and a dummy that identifies the individuals who were affected by the Haby reform. The effect of social status is estimated by looking at the difference between the post- and the pre-Haby cohorts in the difference between the impacts of any two education levels. In the statistical models, smoking is increasing in a linear index *I* specified as follows:

$$\mathrm{I}_{\mathrm{it}}=\boldsymbol{\alpha}\times ln(PRICE)\times E_i + \boldsymbol{\beta}\times ln(PRICE)\times 1\{t\geq 1976\}\times E_i+\boldsymbol{\gamma}\times E_i+\boldsymbol{\delta_0}\times HABY+\boldsymbol{\delta_1}\times E_i\times HABY +\boldsymbol{\lambda}\times \mathrm{X}_{\mathrm{it}}+\varepsilon_{\mathrm{it}} \quad \textbf{(7)}$$

where *i*, *t* index individuals and time respectively, *PRICE* is the price at time *t* (there are no regional price variations), $1\{t>1976\}$ is a dummy variable that equals 1 if *t* is higher than 1976, HABY is a dummy variable that equals 1 if the individual is born in 1966 or after, X_{it} is a vector of control variables and ε_{it} is a random error.

In this specification, education should be negatively correlated with smoking: γ should be negative. The prediction about the effect of relative education implies that, for any given education level, the Haby reform increased the gap from the top education level (which is taken as the reference): δ_1 should also be negative.

An interaction between the education-specific price elasticities and a time dummy for the post-Veil's law period helps us to control for education-related differences in exposure to public policies, since price and information policies were coordinated after 1976. As most of the variables included in the data set have been determined simultaneously with smoking decisions, we cannot control for other observed heterogeneities beyond gender and polynomial gender specific trends in cohort effects. The statistical techniques control for any remaining unobserved heterogeneity that would be uncorrelated with the r.h.s. variables. Table A.2 in Appendix A defines the variables and reports descriptive statistics for the whole sample and the sub-sample of lifetime smokers.

4.2 Econometric modelling

This paper focuses on the decisions to start and quit smoking. Following the methodology developed Forster and Jones (2001), we build two specific panel data sets from our macro data on prices and education level and our micro data on smoking histories. For starting, using the birth date and the age at the time of the survey, we are able to identify the calendar year in which an individual started smoking.[7] We then expand the data set by the age of starting for smokers or former smokers and the current age for never smokers (N=45610 individual-years observations).

Inferences on quitting use the sub-sample of smokers and former smokers. We expand each individual observation in the data set by the smoking duration (N=25224 individual-years observations). A dummy variable indicates whether the individual quit or not in that calendar year. Current smokers represent right-censored spells and former smokers completed spells.[8] Some information on the last attempt to quit is available but is not precise enough to allow a multiple spells treatment of smoking, quits and relapses. In both pseudo-panels, we can link individual observations to price series using calendar years: one observation corresponds to an individual in a calendar year with the associated price.

To analyze the decision to start, a simple estimation strategy is to estimate a probit model over the panel of 45610 individual-year observations. In this case, the dependent variable is a dummy that measures whether individual i started in year t. However, one may also consider that the outcome of interest – smoking initiation – follows a duration process. In this case, define a dummy C that indicates whether someone is a lifetime smoker ($C = 1$) or not ($C = 0$), and denote by T the age of starting. An important feature of the data set is that many individuals have not started smoking at the time of the survey. For them, T is the age at the time of the survey. Given the shape of the hazard function in Figures A3 and A4 in Appendix A, it is unlikely that individuals who did not start before age 30 will do so later. As such, any standard duration model will be misspecified. Douglas and Hariharan (1994) solve this issue by the means of a split-population duration model (SPDM). The idea underlying the SPDM is that the population of individuals who did not start smoking at the time of the survey can be split into two latent classes according to a latent unobserved risk factor R^*. The first class groups individuals who will never start smoking ($R^* = 0$), and the second one gathers those individuals who will eventually become smokers ($R^* = 1$). The probability of being at risk ($R^* = 1$) is modelled as a probit function of a vector of time-invariant covariates. Since the price is not time-invariant, we replace it in this probit equation by the average cigarette price over the main period at risk for starting, *i.e.* between ages 14 and 20 (*PRICE1420*).[9] Conditionally on being at risk of smoking, we assume that the starting age T follows a log-logistic distribution. The p.d.f. $f(.)$ and the survival function $S(.)$ of T are defined as a function of the vector of covariates $x(t)$, which is time-varying since it includes the price. The empirical probability of observing couples (C,T) is then used to identify the parameters of interest. More details can be found in Appendix B.

For the decision to quit, one may also estimate a probit model over the panel of 25224 individual-years observations, where the dependent variable measures whether the individual quit in the year. An alternative strategy is to take smoking duration as the dependent variable. To determine the right duration models for this analysis, the following approach was applied. First, we used the semi-parametric Cox specification to test the proportional hazard (PH) assumption, which is never rejected with our data. Second, we compared results from Cox regressions to estimates from Weibull regressions. It turned out that they were quite similar. Hence, we only present results from the accelerated failure time version of the Weibull model. Third, we test for the presence of misspecification in the Weibull model using the gamma mixture specification as in Forster and Jones (2001) and a Heckman and Singer approach (see Appendix B).

5 Empirical results

This paper aims to test two predictions. First, whether education is negatively correlated with smoking. Second, social status should be negatively correlated with smoking due to education-related opportunity costs: the education-smoking gradient should be steeper for the cohorts that were affected by the Haby reform. This Section tests these predictions using the econometric tools presented in the previous section. Whatever statistical model we use, a simple specification (Specification 1) is estimated, where smoking is only a function of price, education and control variables. These estimates are contrasted with results from the more flexible equation **(7)** (Specification 2).

5.1 Probit estimates

Table 2 reports the results from simple probit estimates of specifications 1 and 2. In each specification, a quadratic trend in either the age in year *t*, or the smoking duration in year *t* was included in order to control for duration dependence, which appears clearly in the shape of the hazard functions (see Figures A3 to A6 in Appendix A). In the first row of the table, we report the average price elasticity of starting and quitting for the sample (specification 1), which are significant and respectively negative and positive as expected. At the mean of the r.h.s. variables, a 1% price increase induces a negative variation of -1.367% of the starting probability, and the probability of a quit increases by 0.508%. However, a decomposition of the price effects by education levels suggests that education alters the impact of smoking public policies. The estimation of Specification 2 indicates that those individual with a short secondary qualification had a lower propensity to start smoking before the beginning of anti-smoking campaigns in 1976. But the effect of these policies was stronger and statistically significant for the more educated only. It is thus important to control for the education-specific impact of smoking policies.

Our estimates also indicate that, controlling for smoking policies, there is a negative education-smoking gradient that is stronger for the cohorts affected by the Haby reform. Hence, the results in Table 2 are consistent with the predictions of the economic model. We now turn to the estimates of duration models, to check that the results are robust to misspecification.

5.2 Duration estimates

Tables 3 and 4 present estimates of the duration models for the decision to start and quit smoking. Although the results do not differ from the probit estimates in terms of sign and magnitude, they do somewhat in terms of statistical significance.

As shown by estimates in Column 1 and 2 of Table 3, changes in price affect the risk of starting smoking but not the age of starting for those individuals who will eventually start. Using Column 1's estimates, one finds that a permanent price increase of 1% decrease the predicted probability of a start before age 18 by -1.12 percentage points (95% of the sample being in the interval [-1.59 , -0.76]).[10] Specification 2's estimates reveal that Veil's law has had an effect on the price elasticity of the smoking risk but, perhaps surprisingly, this effect is greater for the less-educated individuals and those with a Baccalaureat. Price exerts a negative and significant effect on smoking duration as shown in the first column of Table 4. A 10% price increase lowers the mean smoking duration by about 7.75% (one year at the sample mean duration). Specification 2 decomposes this effect by education level and time period, and the results are quite similar to the probit estimates. Once again, the only significant change in price effects is observed for the more educated (-1.649).

As in the cross-tabulations of Section 3, there is a clear relationship, in these data, between education and smoking. Hence, the first prediction of the model holds when one controls both for changes in smoking policies and relative education levels.

In Tables 3 and 4, the second specification adds interactions between education and the HABY dummy to identify the effect of changes in the relative level of education. While such changes had no impact on starting, the correlation between education and smoking duration is clearly affected. Indeed, the education-quitting gradient strongly increased as a consequence of the Haby reform. Hence, relative education matters, but for quitting only.

Table 2. Decisions to start and quit - Probit estimates.

Dependent variable	**Start in year *t***		**Quit in year *t***	
Specification	**1**	**2**	**1**	**2**
PRICE in year t				
Log(PRICE)	-0.363*** (0.070)		0.205* (0.108)	
Log(PRICE) * NOQUAL / CEP		0.063 (0.259)		-0.602 (0.486)
Log(PRICE) * BEPC / CAP		-0.488** (0.191)		-0.382 (0.441)
Log(PRICE) * Bac		-0.133 (0.357)		-0.441 (0.665)
Log(PRICE) * Bac2 / Bac3+		0.126 (0.281)		-0.973* (0.522)
Log(PRICE) * after 1976 * NOQUAL / CEP		-0.271 (0.238)		0.533 (0.452)
Log(PRICE) * after 1976 * BEPC / CAP		-0.106 (0.163)		0.565 (0.405)
Log(PRICE) * after 1976 * Bac		-0.200 (0.314)		0.569 (0.634)
Log(PRICE) * after 1976 * Bac2 / Bac3+		-0.414* (0.245)		1.135** (0.501)
Education E (ref: Bac2/Bac3+)				
NOQUAL / CEP	0.268*** (0.041)	0.182** (0.084)	-0.225*** (0.059)	-0.155* (0.087)
BEPC / CAP	0.196*** (0.034)	0.014 (0.077)	-0.137*** (0.049)	-0.037 (0.073)
Bac	0.106** (0.042)	0.042 (0.101)	0.020 (0.061)	0.101 (0.092)
NOQUAL / CEP * HABY		0.243*** (0.091)		-0.349** (0.141)
BEPC / CAP * HABY		0.157** (0.073)		-0.215** (0.106)
Bac * HABY		0.088 (0.094)		-0.181 (0.130)
Other control variables				
HABY		0.012 (0.066)		0.322*** (0.103)
Male	-0.484*** (0.120)	-0.471*** (0.120)	-0.585*** (0.204)	-0.500** (0.202)
AGE in 2001/10 * Female	-0.144*** (0.022)	-0.061* (0.033)	-0.103** (0.047)	-0.073 (0.062)
AGE in 2001/10 * Male	0.035 (0.023)	0.114*** (0.034)	0.026 (0.044)	0.035 (0.059)
AGE in year *t* (start) or smoking duration in year *t* (quit)	0.389*** (0.021)	0.392*** (0.021)	0.037*** (0.009)	0.045*** (0.010)
Squared AGE in year *t* (start) or squared smoking duration in year *t* (quit)	-0.019*** (0.001)	-0.019*** (0.001)	-0.001** (0.000)	-0.001** (0.000)
Constant	-3.101*** (0.117)	-3.369*** (0.174)	-1.836*** (0.160)	-2.186*** (0.251)
N Individual-year	45610	45610	25224	25224
N Individual	2589		1444	
Log-likelihood	-5367.12	-5354.23	-2288.44	-2277.09

Note : Standard errors in parentheses clustered on individual observations. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 3. Decision to start – duration models

Specification	**1**		**2**	
Equation	**Risk: R***	**Starting Age: T**	**Risk: R***	**Starting Age: T**
PRICE				
Log(PRICE1420) / Log(PRICE)	-0.976*** (0.270)	0.004 (0.099)		
Log(PRICE1420) / Log(PRICE) * NOQUAL / CEP			0.114 (0.373)	-0.160 (0.211)
Log(PRICE1420) / Log(PRICE) * BEPC / CAP			-0.542* (0.290)	0.067 (0.138)
Log(PRICE1420) / Log(PRICE) * Bac			0.008 (0.465)	-0.137 (0.277)
Log(PRICE1420) / Log(PRICE) * Bac2 / Bac3+			-0.271 (0.355)	-0.030 (0.197)
Log(PRICE1420) / Log(PRICE) * after 1976 * NOQUAL / CEP			-1.614*** (0.593)	0.076 (0.279)
Log(PRICE1420) / Log(PRICE) * after 1976 * BEPC / CAP			-0.651 (0.403)	-0.005 (0.162)
Log(PRICE1420) / Log(PRICE) * after 1976 * Bac			-1.472** (0.580)	0.399 (0.275)
Log(PRICE1420) / Log(PRICE) * after 1976 * Bac2 / Bac3+			-0.259 (0.441)	-0.107 (0.210)
Education E (ref: Bac2/Bac3+)				
NOQUAL / CEP	0.337*** (0.077)	-0.211*** (0.029)	0.286* (0.159)	-0.215*** (0.045)
BEPC / CAP	0.296*** (0.063)	-0.142*** (0.024)	0.121 (0.154)	-0.093** (0.042)
Bac	0.157* (0.082)	-0.082** (0.032)	0.184 (0.206)	-0.055 (0.056)
NOQUAL / CEP * HABY			0.099 (0.241)	0.039 (0.165)
BEPC / CAP * HABY			0.093 (0.208)	0.014 (0.131)
Bac * HABY			-0.203 (0.256)	0.134 (0.178)
Other control variables				
HABY			-0.163 (0.183)	-0.094 (0.105)
Male	-0.815*** (0.229)	0.187** (0.086)	-0.848*** (0.232)	0.171** (0.085)
AGE in 2001/10 * Female	-0.005 (0.067)	0.105*** (0.025)	-0.178*** (0.068)	0.074*** (0.027)
AGE in 2001/10 * Male	0.305*** (0.069)	0.045* (0.026)	0.138** (0.069)	0.018 (0.027)
Constant	-0.408 (0.312)	1.775*** (0.114)	0.443 (0.335)	1.892*** (0.126)
Log-likelihood	-5177.9		-5157.0	

Note : Standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. In both model the shape parameter of the log-logistic function is about 0.2 and significant at the 1% level. N=2589.

Table 4. Decision to quit - duration models

Specification	**1**	**2**
Dependent variable	**Smoking Duration**	**Smoking Duration**
PRICE		
Log(PRICE)	-0.775*** (0.212)	
Log(PRICE) * NOQUAL / CEP		0.145 (0.921)
Log(PRICE) * BEPC / CAP		-0.202 (0.860)
Log(PRICE) * Bac		0.025 (1.239)
Log(PRICE) * Bac2 / Bac3+		0.949 (0.894)
Log(PRICE) * after 1976 * NOQUAL / CEP		-0.459 (0.889)
Log(PRICE) * after 1976 * BEPC / CAP		-0.644 (0.798)
Log(PRICE) * after 1976 * Bac		-0.709 (1.188)
Log(PRICE) * after 1976 * Bac2 / Bac3+		-1.649* (0.885)
Education E (ref: Bac2/Bac3+)		
NOQUAL / CEP	0.418*** (0.113)	0.256* (0.154)
BEPC / CAP	0.235*** (0.091)	0.027 (0.128)
Bac	-0.046 (0.112)	-0.190 (0.160)
NOQUAL / CEP * HABY		0.632** (0.269)
BEPC / CAP * HABY		0.395** (0.192)
Bac * HABY		0.301 (0.232)
Other control variables		
HABY		-0.562*** (0.183)
Male	1.184*** (0.387)	0.946** (0.369)
AGE in 2001/10 * Female	0.130* (0.077)	0.018 (0.102)
AGE in 2001/10 * Male	-0.135* (0.079)	-0.190* (0.101)
Constant	2.844*** (0.303)	3.521*** (0.452)
Log-likelihood	-1184.6	-1175.4

Note: Standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. N=1444.

6 Discussion

6.1 Adolescence and the peculiarities of the starting decisions.

The duration models estimates reveal that the probit results were misleading for starting. The results also indicate that the Haby reform did not affect the gradient between education and lifetime smoking. Hence, the second prediction of the model is rejected. As starting takes place mainly during adolescence, one interpretation of this result is that adults' representations of social status are not valid for understanding adolescent behaviours. While the teenagers may be over-pessimistic about their future (a very low β in equation **(6)**), they tend above all to value the consequences of smoking in a very particular way (O'Donoghue and Rabin, 2000). Special rewards from smoking include peer reactions, which are fairly independent from social status. Further, assuming that the social status, which is proxied in our model by the relative education level, enter in the adolescent's well-being function might be false. This interpretation is supported by empirical findings on French data that adolescent selection into smoking is rather independent from the father's social status and, therefore, from the teenager's expected social status (Etilé, 2004).

6.2 Unobserved heterogeneity and endogeneity

Unobserved heterogeneities such as time preferences or cognitive ability may blur the empirical link between education and smoking. If one considers that individuals can make investments to lower their discount rate, schooling may affect smoking through changes in time preferences, which would be of little importance in the context of the current paper. But, one is more likely to imagine that preference for the present determines simultaneously schooling choices and health-related behaviour (Farrell and Fuchs, 1982, Grossman, 2004).

Unobserved heterogeneities in cognitive ability may also induce a downward bias in the correlation between education and smoking with respect to the true causal effect of education on smoking. In a recent paper, Auld and Sidhu (2005) find in American data that cognitive ability may affect efficiency in health production not only though accumulation of human capital E, but also directly, especially for the more educated individuals. Section 2's model assumes that education *per se* affects the efficiency in information use, but also that there may be some signalling on the labour market: individuals have different cognitive abilities that determine their productivity, and they use investments in education as a signal on the labour market. In this case, the Haby reform may have had a negative impact on the average efficiency associated to a given education level.

This may explain that we find a stronger education-smoking duration gradient for the cohorts that were affected by the Haby reform.

Unobserved heterogeneities render education endogenous in equation (9). Solving the endogeneity issue requires ideally a joint modelling of the schooling and the smoking decisions and, therefore, instruments for schooling.[11] Given the retrospective nature of our data and the lack of information on individual's schooling decisions, there is no instrument in our datasets. However, since quadratic cohort trends have no effect on smoking duration and a fairly significant effect on education for the individuals who were affected by the Haby reform, it is possible to instrument schooling by cohort trends. An augmented regression approach is implemented, where in a first step a probit model for the education level is estimated. The dependent variable here is BAC&UNDER, which takes the value 1 if the individual has not a post-baccalaureat degree. The generalized residual from this estimation is then computed and introduced in a second step in the duration model. Appendix B gives more details and Table 5 presents the results from this two-steps procedure. The estimates do not reject the null hypothesis that education is exogenous in the duration model, as the generalized residual has no impact on smoking duration. Hence, at least for the younger cohorts, there appears not to be a third factor that would explain the correlation between education and the smoking duration.

Table 5. Test of endogeneity – augmented regression results

Model	**Weibull model – Specification 1**	**Probit model**	**Weibull model – Specification 1**
Dependent variable	**Smoking duration**	**BAC&UNDER**	**Smoking duration**
LOG(PRICE)	-0.983* (0.529)	-1.828*** (0.452)	-1.079* (0.585)
BAC&UNDER	0.502*** (0.130)		0.497*** (0.131)
Generalized residual from the probit for BAC&UNDER			0.052 (0.303)
Male	-2.325 (8.306)	-3.636 (4.571)	1.558 (1.228)
AGE in 2001/10 * Female	0.793 (3.021)	-13.864*** (2.556)	0.046 (0.261)
AGE in 2001/10 * Male	3.088 (5.030)	-11.431*** (2.534)	-0.363 (0.403)
(AGE in 2001/10)^2	-0.126 (0.516)	2.367*** (0.441)	
(AGE in 2001/10)^3	-0.593 (0.857)	2.004*** (0.446)	
Constant	1.821 (4.414)	19.358*** (3.598)	2.848*** (0.937)

Note: * significant at 10%; ** significant at 5%; *** significant at 1%. Sub-sample of individuals born after 1965. N=628.

6.3 Efficiency vs. opportunity costs

According to the model's predictions and our results, the changes in relative education induced by the Haby reform affected the education-smoking gradient by modifying the education-related opportunity cost of smoking. Efficiency played a minor role. However, a key question remains whether for a given education level the ability to understand health warnings is lower in the younger cohorts. Was the general human capital associated to any education level, and therefore the capability to understand health warnings, lower after the Haby reform? There are very few studies on trends in performances by education levels for France. In one careful analysis of this question, Baudelot and Establet (1989) compared results for the armed force qualification test by education level for the conscription cohorts drafted in 1967 and 1982. The scores to the test were slightly lower in the younger cohort only for the individuals with a BEPC or a CAP.

Another way to look at the efficiency argument is to examine the price elasticities by education levels in Table 4. What is the prediction of the model concerning an exogenous shock on available information Ω? Differentiating equation **(4)** with respect to Ω and c_1 yields:

$$dc_1 = -\frac{\beta\pi_{cK} h_{\Omega} V}{u_{cc} + \beta\pi_{cc} V} d\Omega \quad \textbf{(8)}$$

Hence, the consumption should fall because information renders the opportunity cost of smoking more salient. If one is willing to assume that π is only linear in c and π_{cK} is a constant, then one also finds that the decrease in consumption is more important for the more educated. Indeed, π_{cc}=0 implies:

$$\frac{d\left(dc_1 / d\Omega\right)}{dE} = -\frac{\beta' \pi_{cK} h_{\Omega} V + \beta\pi_{cK} h_{\Omega E} V + \beta\pi_{cK} V_E}{u_{cc}} \quad \textbf{(6)}$$

which is negative because the more educated are more efficient ($h_{E\Omega}$>0), they have a lower discount factor (β'<0) and they face higher opportunity costs (V_E>0).

The more educated should have been more affected by the release of health warnings. Since information and price policies were coordinated after 1976, the price elasticities should be lower after 1976, and that the variation in price elasticities between the pre- and post-1976 periods should increase with education. However, there is no such gradient in Table 4's results between individuals who did not achieve a post-Baccalaureat degree. Since there are more differences in terms of human capital between those who have a Baccalaureat and those who have no Secondary School degree, than between those who have a Baccalaureat and those who have a post-Baccalaureat degree, the efficiency argument alone does not explain the result. The latter is actually more compatible with the opportunity cost explanation. First, the breaks in price elasticities are identified essentially by changes in the smoking behaviour of individuals from the younger birth cohorts. Second, Goux and Maurin (1994) show that, in these birth cohorts, the returns to the Baccalaureat, the BEPC/CAP and the Noqual/CEP education levels have converged over the last thirty years (even after adjustment for the risk of unemployment). Hence, differences in opportunity costs are more relevant for explaining the differences of variations in the price elasticity by education levels.

However, one may argue that a potential confounder is addiction, which lowers short-term price responsiveness because more addicted smokers are more likely to face concave adjustment costs (Suranovic *et al.*, 1999). To examine more formally this argument, we test for each education level the existence of a positive break in the price elasticity after T_1 years of smoking: does the price elasticity increase with smoking duration? These regressions are run separately by education levels, and we restrict our attention to the post-1976 period. The optimal breakpoint is determined by comparing the log-likelihood of the estimates of Cox semi-parametric statistical models (Pons, 2002). As addiction and smoking duration are positively correlated, one expects long-term smokers to have greater adjustment costs and to be less price responsive.

Table 6. Price elasticities after 1976 and addiction by education levels

Subsample (number of individuals)	**Break-point**	**Price elasticity before the break**	**Price elasticity after the break**
NOQUAL / CEP (N = 292)	9 years	-4.828***	-1.492
BEPC / CAP (N = 588)	15 years	-1.114**	-0.253
Bac (N=206)	No positive break detected	-1.103	
Bac 2 / Bac3+ (N=328)	No positive break detected	-0.550	

Note: * significant at 10%; ** significant at 5%; *** significant at 1%. Cox models regressions results. Control variables : gender, gender*cohort trends, Haby, education level, Haby*Education level. Regressions by sub-samples with selection on education levels as shown in the first column.

Estimates from Table 6 indicate that the "optimal" breakpoint is at T_1=9 and T_1=15 years of smoking respectively, for those with the lowest levels of education and those with a BEPC or a CAP. Before this break occurs, the price elasticity are significant and equal -4.828 and -1.114

respectively, so that the less educated are more price responsive than the more educated. But after the break, the price elasticity of the less educated decreases and becomes insignificant, albeit always negative. Since the small sub-samples sizes may explain these results, we checked that these results are robust by grouping the four bottom education levels on the one hand and the top three education levels on the other hand. No break was found for the more educated, and a break at T_1=15 years of smoking was detected for those with a degree lower than the Baccalaureat.

Table 7. Structural breaks in price elasticities after 1976 by education levels and smoking duration

Education level	**LOG(PRICE)**	**LOG(PRICE)* after 1976**	**LOG(PRICE)* after 1976 * smoking duration greater than 14 years**
NOQUAL / CEP	0.006	-0.805	0.847
BEPC / CAP	-0.445	-0.929	1.129**
Bac	0.133	-0.428	-1.379
Bac2 / Bac3+	0.843	-1.759*	0.510

Note: * significant at 10%; ** significant at 5%; *** significant at 1%. This specification adds to specification 2 of Table 3 an interaction between LOG(PRICE), the education level, a dummy for the 1976's break and a dummy for smoking durations greater than 15 years.

To see how the "unobserved addiction" factor bias Table 4's results, Table 7 above re-estimates specification 2 with interactions between the price elasticity, the education level, a dummy for the 1976 break, and a dummy that identifies individual-year observations associated to a smoking duration greater than 14 years. The point estimates reported in the third column show that there is definitely no education gradient in the variations of price elasticity for education levels under post-Baccalaureat degrees, when one controls for adjustment costs.

That efficiency does not explain the current education-smoking gradient does not mean that it did not play a role before Veil's law. The price elasticity of quitting was actually positive, although not significant, for the more educated before 1976. As shown in Figure 2, cigarette prices steadily decreased before this date. Hence, this fall in price was correlated with a decrease in consumption, perhaps because the information about the risks of smoking was already diffusing in this population. Hughes (2003) notes that there had been a shift in medical understanding of tobacco-related morbidity in the late 1930's, when the first epidemiological data began to emerge. Physicians' membership of more educated social classes may then have favoured a faster spread of health-based anti-tobacco arguments among the more educated, especially in the 1950's and the 1960's.[12] As such, the rise in aggregate consumption that can be observed in Figure 2 was mainly driven by the upward trend in female smoking. The latter clearly appears in Table 4's regressions.

7 Conclusion

This paper has investigated the evolution of the education-smoking gradient in France over the second half of the past century, using time series of price data and a recent individual data set containing retrospective information on smoking histories. This section sums up our main findings.

The education-smoking gradient may be thought of as an effect of the absolute education level, or of the relative education level. In spite of the massive increase in the population education level that occurred in the last century, the education-smoking gradient persists, so that the relative education level may be a determinant of smoking behaviour as important as the absolute level of education. We use a major reform of the education system, the Haby reform, to provide some evidence in favour of this explanation. This reform was designed to improve the population‘s education, by creating new educational tracks and lowering the selection hurdles, at the time of the first oil crisis and the rise of mass unemployment. Perhaps as a consequence, returns to basic schooling, short Secondary School degrees and long Secondary School degrees have begun to converge over the last thirty years, precisely for the birth cohorts affected by the Haby reform. Descriptive statistics and simple probit estimates show that education has more effect on the decisions to start and to quit smoking for these birth cohorts. However, duration analysis reveals that, controlling for changes in smoking policies, this result holds only for the decision to quit.

Our model in Section 2 shows that differences in education-related opportunity costs may explain this result if there is signalling on the labour market or/and when utility is relative. Under these assumptions, the opportunity costs associated with a qualification are lower when more people have access to this qualification, because the labour market value of the qualification decreases or/and the relative social status (correlated with education) is an argument of the utility function. Furthermore, as public health warnings began to be disseminated after 1976 in coordination with tax increases, one expects greater price elasticity after 1976 than before, and the variation in the price elasticity should be positively correlated with education, because the more educated are more capable to understand health warnings and they face higher opportunity costs. We do not find a connection between education and the variations in price elasticity for qualifications lower than the university degree, while the more educated clearly changed their behaviour after 1976. Since, in theory, efficiency should continuously vary with education, our results suggest that differences in education-related opportunity costs explain for adult populations the persistence of the education-smoking gradient in an era where almost all individuals are well-informed about the dangers of smoking.

Our findings have an important consequence for the welfare analysis of smoking policies. For low-income/less educated smokers, health benefits from tax increases will largely be offset by a negative redistributive effect: since tax increases have a small effect on their propensity to smoke (see Table A3 in Appendix A), tobacco taxes are regressive. Conversely, it would be interesting to test whether redistributive and labour market policies have an indirect effect on the social heterogeneity of health behaviours by the reduction of heterogeneities in opportunity costs[13]. This is left for future research.

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Appendix A. Data

Table A.1. Definition of qualifications with international equivalents

Variable's name	Educational programmes (French name)	Description with some U.K. and/or U.S. equivalents	ISCED-97 level
NOQUAL	No qualification	No qualifications	0
CEP	Certificat d'Etudes Elémentaires (C.E.P.), Diplôme de fin d'étude obligatoire.	No equivalent certification for adult literacy and numeracy	1
BEPC	Brevet des collèges (B.E.P.C.), Brevet d'Enseignement Primaire Supérieur, Brevet Elémentaire.	Certification for having completed the first stage of secondary school: *cf.* grade 9 in the U.S.A., Certificates of Secondary Education grades 1-5 in the U.K.…	2A
CAP	Certificat d'Aptitude Professionnelle (CAP), Brevet d'Etudes professionnelles.	Vocational Qualifications: *cf.* GNVQ Foudation and Intermediate levels in U.K.	3C
Bac	Baccalauréat (general, technical or vocational), Baccalauréat (first part), Certificat de fin d'études secondaires, Brevets professionnels, Brevet supérieur.	National Diplomas which certify High School vocational, professional or general studies: *cf.* GCE A– and S-level or GNVQ A-level in U.K., High School Diploma in the U.S.A..	3A, 3B, (3C)
Bac2	Bac+1 and Bac+2	Programmes in 1 or 2 years after the Baccalaureat: *cf.* Vocational Certificate or Academic Associates's Degree Programme in the U.S.A., Higher National Diploma etc. in U.K..	4A, 4C, 5B, (5A with first two years of university successfully completed).
Bac3+	Bac+3 and more	Programmes in more than 2 years after the baccalaureat	5A with at least three years at the university completed, other 5A, 6.

Figure A1: Time Changes in the Distribution of Qualifications, Female Cohorts.

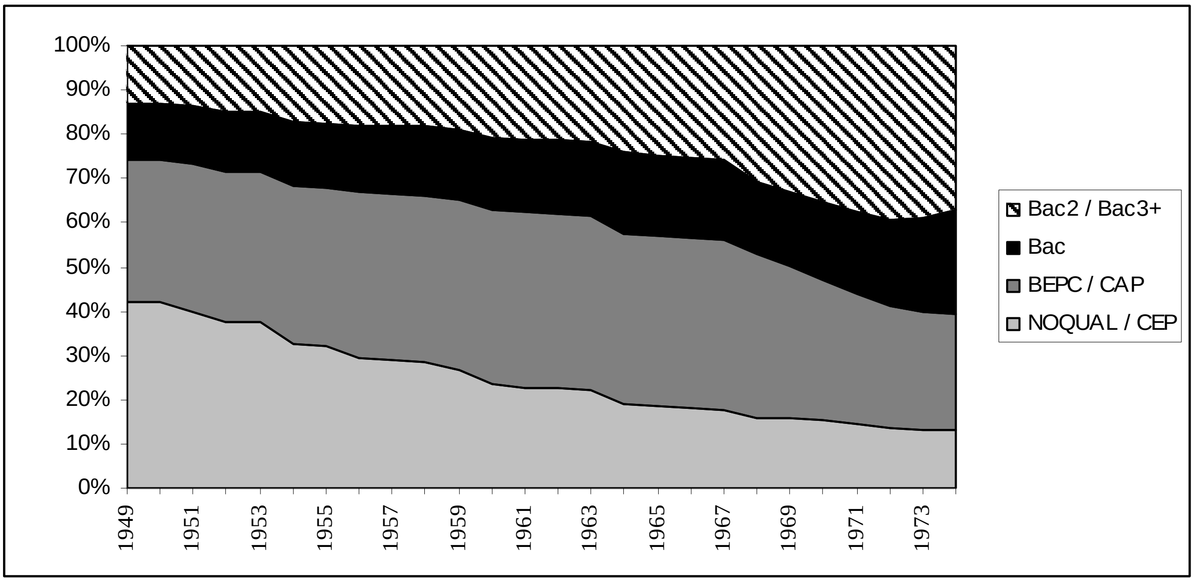
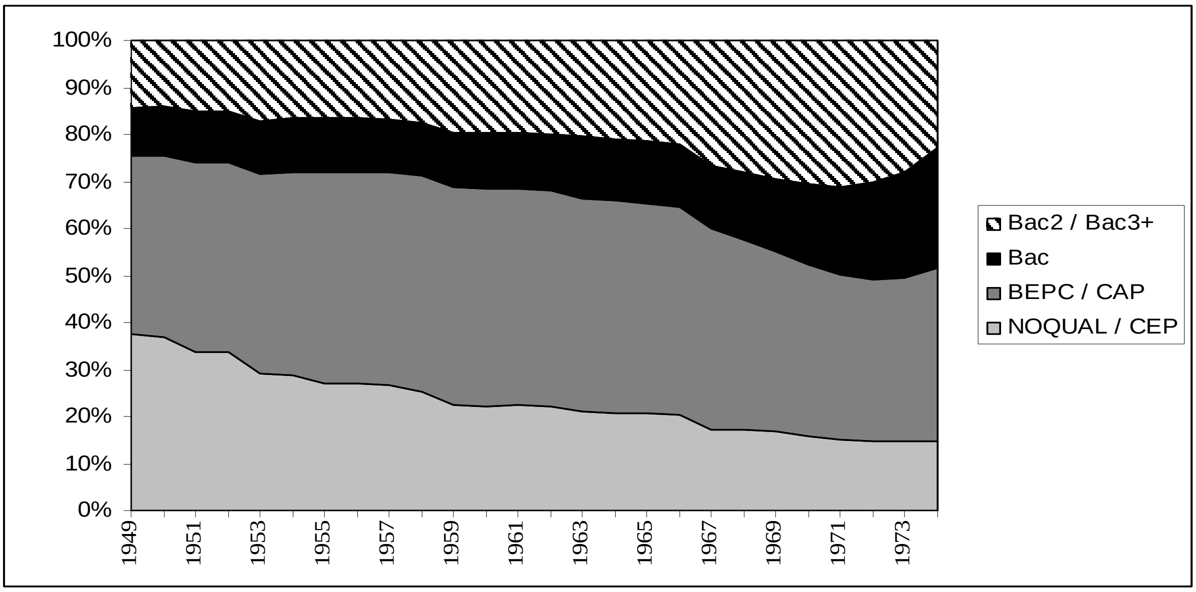


Figure A2: Time Changes in the Distribution of Qualifications, Male Cohorts.



Notes: these distributions of qualifications by gender and cohort were computed using aggregate results from five cross-sectional surveys that were nationally representative of the population living in France: the surveys "Formation et Qualification Professionelle" (1970, 1977, 1985, 1993) and the 1999 National Census.

Figure A3. Hazard of Starting Smoking by Education and Cohorts, Females Only.

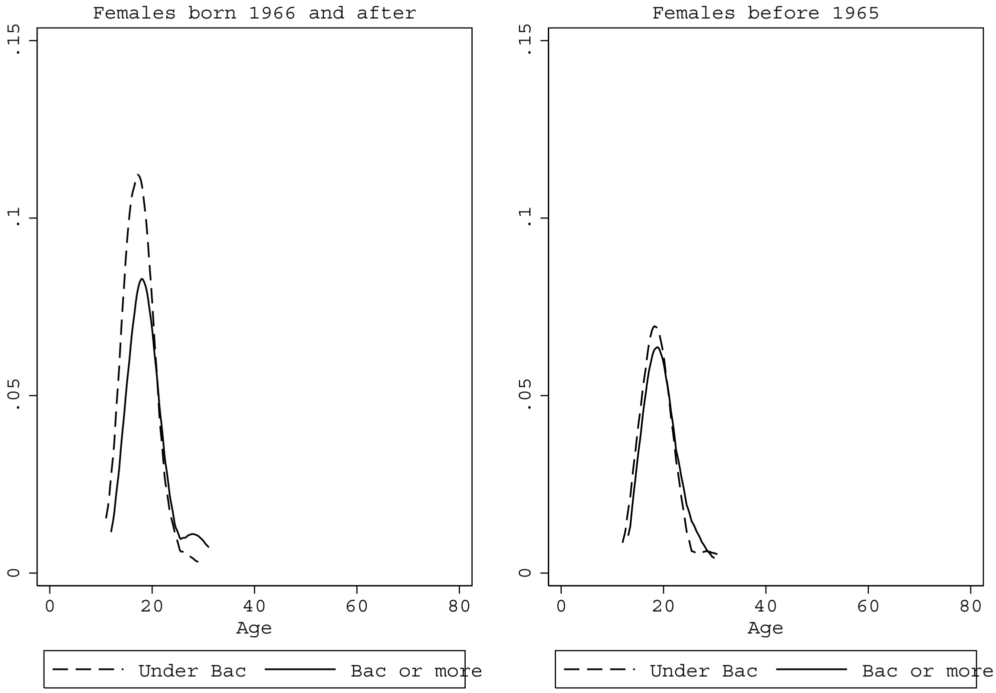


Figure A4. Hazard of Starting Smoking by Education and Cohorts, Males Only.

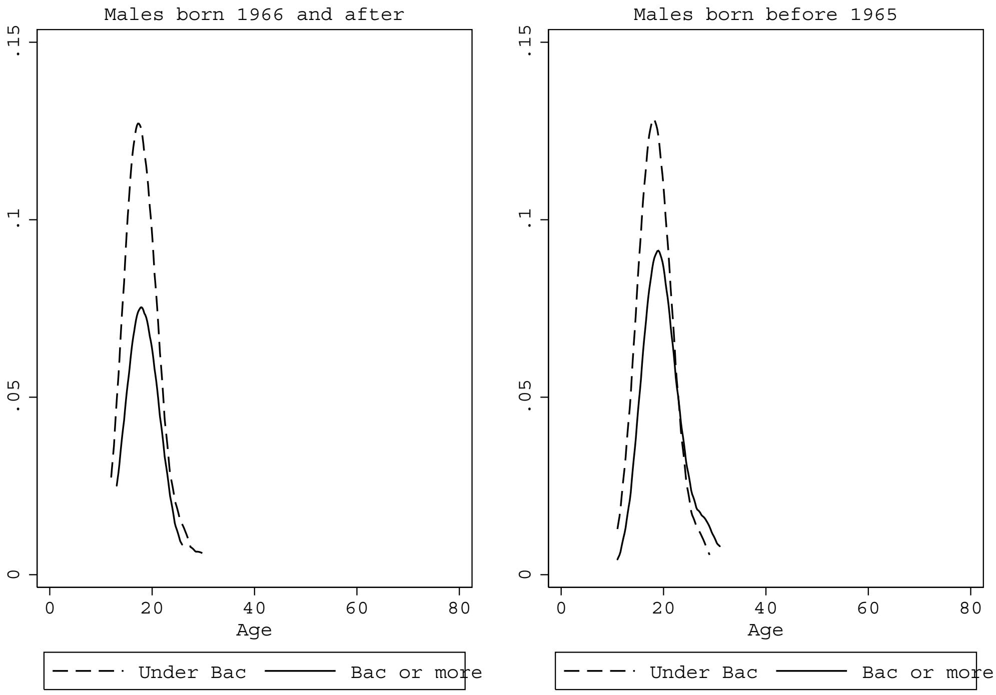


Figure A5. Hazard of Quitting Smoking by Education and Cohort, Females only.

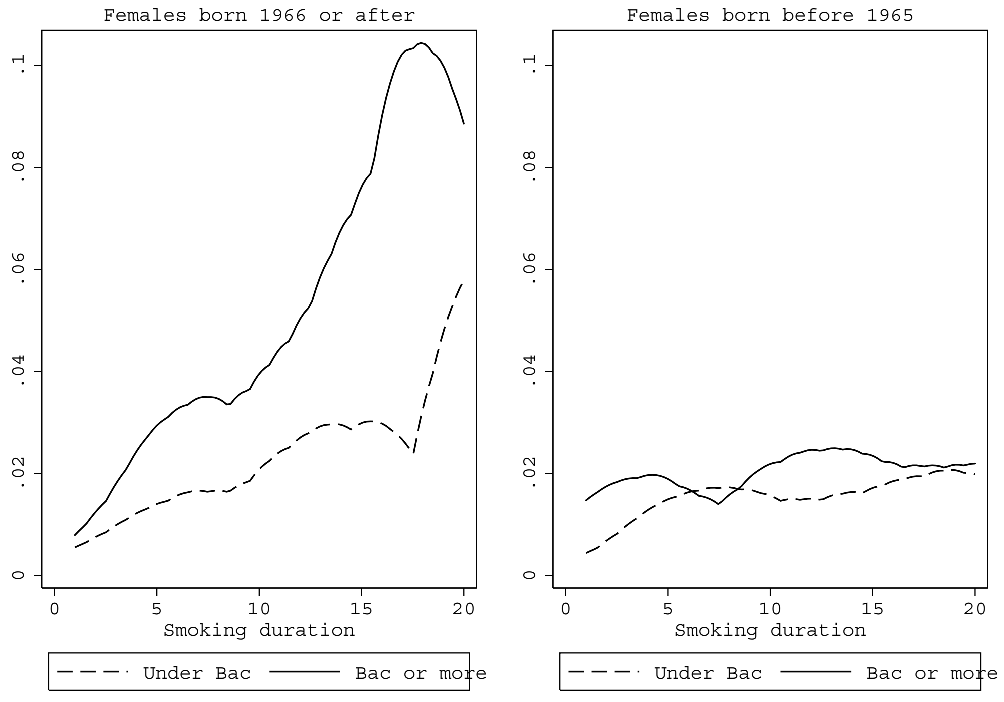


Figure A6. Hazard of Quitting Smoking by Education and Cohort, Males only.

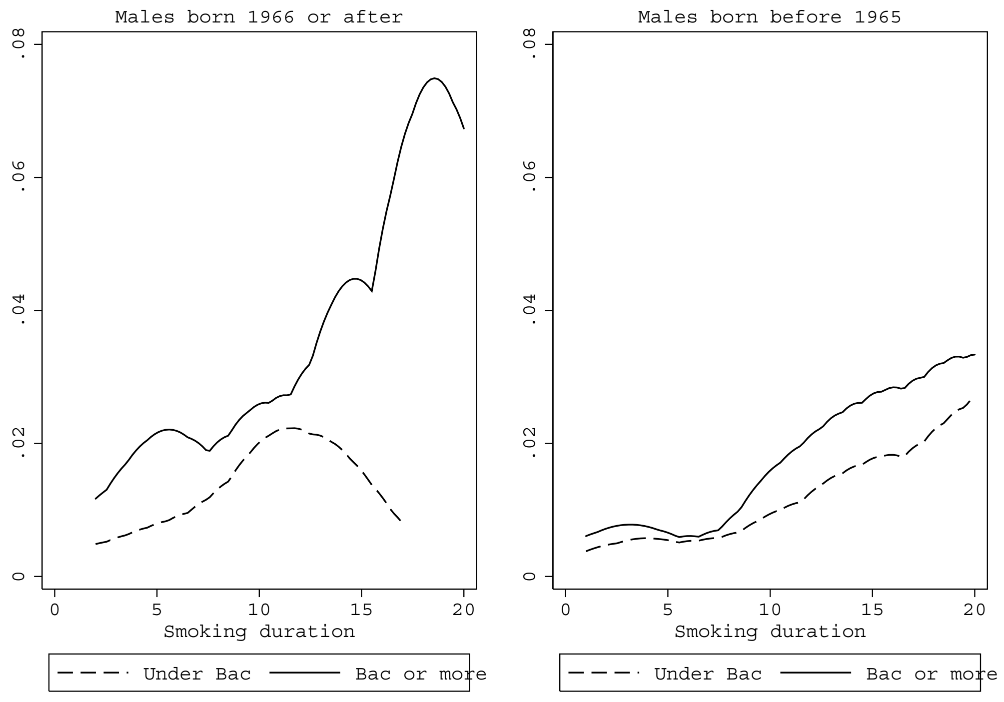


Table A2. Name and sample means of the variables

Variable	**N**	**Sample mean**
Lifetime smoking	2589	55.80%
Starting Age	1444	17.51
Quits	1444	32.76%
Average smoking duration	473	13.14
Male	2589	46.40%
Age	2589	37.04
HABY	2589	42.60%
NOQUAL / CEP	2589	21.50%
BEPC / CAP	2589	38.71%
Bac	2589	14.99%
Bac2 / Bac3+	2589	26.81%

Table A3. Price elasticities by period & education levels

Period	***Before 1976***			***After 1976***		
Dependent variable	**Risk: R***	**Starting Age: T**	**Smoking Duration**	**Risk: R***	**Starting Age: T**	**Smoking Duration**
NOQUAL / CEP	0.114	-0.160	0.145	-1.501***	-0.084	-0.314
BEPC / CAP	-0.542*	-0.067	-0.202	-1.193***	0.062	-0.845***
Bac	0.008	-0.137	0.025	-1.463***	0.262	-0.684*
Bac2 / Bac3+	-0.271	-0.030	0.949	-0.530	-0.137	-0.700***

Note: * significant at 10%; ** significant at 5%; *** significant at 1%. Results from estimations of Model 2 with interactions between log(PRICE) and time dummies for the pre- and post-Veil's law periods.

Appendix B. Econometric Methods

Starting

The probability of being at risk for starting is specified as follows:

$$\begin{cases} \Pr(\text{eventually start smoking}) = \Pr(R^* = 1) = \Phi(Z_i \alpha) \\ \Pr(\text{never start smoking}) = \Pr(R^* = 0) = 1 - \Phi(Z_i \alpha) \end{cases} \quad \textbf{(B1)}$$

where Z_i is a vector of time-invariant covariates, Φ is the standard normal c.d.f. and α is a parameter vector. The p.d.f. $f(.)$ and the survival function $S(.)$ of the age of starting T are defined as:

$$\begin{cases} f\left(T \middle| R^* = 1, x(\tau), \tau = 1...T\right) = S\left(T \middle| R^* = 1; x(\tau), \tau = 1...T\right) \dfrac{\lambda^{1/\gamma} T^{1/\gamma - 1}}{\gamma \left\{1 + (\lambda T)^{1/\gamma}\right\}} \\ S\left(T \middle| R^* = 1; x(\tau), \tau = 1...T\right) = \prod_{\tau=1}^{T} \dfrac{S(\tau | x(\tau))}{S(\tau - 1 | x(\tau))} \end{cases} \quad \textbf{(B2)}$$

$$\text{with } S\left(\tau_1 \middle| x(\tau_2)\right) = \frac{1}{\left\{1 + (\lambda \tau_1)^{1/\gamma}\right\}} \text{ and } \lambda = \exp\left(-x(\tau_2)\beta\right)$$

Hence, the index I_{it} of equation **(7)** is $x(\tau)\beta$ in the duration equation of the model, and $Z\alpha$ in the probit equation. When γ is lower than 1, the hazard is increasing and then decreasing in τ. We are interested in the identification of the joint distribution of T and C. For lifetime smokers, we necessarily have $R^* = 1$ and $C = 1$. Hence, their contribution to the likelihood is simply:

$$\begin{aligned} \Pr(T, C = 1) &= \Pr\left(T, C = 1 \middle| R^* = 1\right) \Pr\left(R^* = 1\right) \\ &= f\left(T \middle| R^* = 1; x(\tau), \tau = 1...T\right) \Phi(Z\alpha) \end{aligned} \quad \textbf{(B3)}$$

Those who are observed as not starting are either not at risk ($R^* = 0$) or at risk but the risk event did not occur ($R^* = 1$ but $C = 0$). Their contribution to the likelihood is:

$$\Pr(T, C=0) = \Pr\left(R^* = 0\right) \underbrace{\Pr\left(T, C=0 \middle| R^* = 0\right)}_{=1} + \Pr\left(T, C=0 \middle| R^* = 1\right)$$
$$= \left(1 - \Phi(Z\alpha)\right) + \Phi(Z\alpha) S\left(T \middle| R^* = 1; x(\tau), \tau = 1 \ldots T\right) \qquad \textbf{(B4)}$$

The distribution of *T* is then parametrically identified by the maximisation of the log-likelihood function for which individual *i*'s contribution is:

$$\mathrm{LnL}\left(T_i, C_i \middle| x_i(\tau), \tau = 1 \ldots T_i\right) = C_i \ \ln\left\{\Pr\left(T_i, C_i = 1\right)\right\} + \left(1 - C_i\right) \ln\left\{\Pr\left(T_i, C_i = 0\right)\right\} \qquad \textbf{(B5)}$$

Since the SPDM is a degenerate mixture model, we estimate it by E-M. algorithms, and compute the variance by the inverse of the hessian matrices.

Smoking Duration

The semi-parametric Cox proportional hazard model specifies the hazard function as a product of an unspecified base-line hazard $h_0(\tau)$ and a proportionality factor $exp(-x(\tau)\beta)$, where $x(\tau)\beta$is the index of equation **(7)**:

$$h_i\left(\tau \middle| x(\tau)\right) = h_0(\tau) \exp\left(x(\tau)\beta\right) \qquad \textbf{(B6)}$$

The Cox estimator works on the partial likelihood for the vector of the ranks of the individuals when their durations are arranged in order of increasing magnitude. This partial likelihood involves neither the base-line hazard nor the times at which exits occur. It relies on the proportional hazard assumption which requires that the ratio of hazards for individuals that are different with respect to any covariates is the same at any point of the time scale. Restricting the base-line hazard in **(B6)** to be $h_0(\tau) = pt^{p-1}$ gives the parametric Weibull proportional hazard, which can yield an increasing hazard rate for *p* greater than 1 as in Figures A5 and A6. Our tests for misspecification are based on those adopted by Forster and Jones (2001). The proportional hazard assumption was never rejected. The (visual) tests of Cox-Snell and Martingale residuals are satisfactory. There may be however some concerns for the modelling of very short and very long smoking durations as shown by the plot of the Martingale residuals. We can also allow for misspecification of the hazard function by replacing the constant in β with an individual specific effect v_i. When e^{v_i} is gamma-distributed with parameters 1/θ and θ, one obtains a gamma-mixture Weibull model. When θ tends to 0, the Gamma-mixture of Weibull collapses to the simple Weibull model, which gives a test of homogeneity. Alternatively, Heckman and Singer (1984) propose a more general approach in which the distribution of ν is left unspecified. They show that the parameters p and β are identified, and can be estimated by using a finite mixture approximation. We estimated a finite mixture of Weibull model using a simulated annealing E-M. algorithm. Using various starting values, we always found identical values for the support points of the discrete distribution, which confirms that unobserved heterogeneity do not affect additively the mean smoking duration.

ENDNOTES

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[1] Fuchs (2004, p. 657) notes : *"To explain the education-health connection, some researchers have proposed that those with more schooling are quicker to act on new health information or take advantage of improvements in medical technology. This seems reasonable, but is it important? The persistence of the negative gradient between education and cigarette smoking many decades after information about the harmful effects of smoking became widespread raises questions about the robustness of this explanation".*

[2] INSEE: National Institute for Statistic and Economic Studies.

[3] The less educated may not have the general knowledge that would allow them to fully comprehend some specific components of this risk, such as everyday disabilities resulting from a chronic obstructive pulmonary disease.

[4] We find actually no education-smoking gradient in these data for the elderly, which could be interpreted as an evidence that the more educated smokers have a lower risk of mortality.

[5] The minimum school leaving age rose from 14 to 16 and new educational tracks were created for individuals born after 1952. As a consequence, Secondary School and University attendance as well as post-Baccalaureat programmes developed vigorously, especially after the Fouchet's reforms in 1963 and 1966, and the Faure's law in 1968.

[6] To obtain sales per capita, sales were divided by INSEE yearly figures for the total population aged over 15 in France.

[7] Since the survey was conducted in May 2001, and the age of starting is given in years without indications of the month, we determined an interval for the calendar year of starting. We had the same problem of imprecision for the time since quitting, which is in years except for a few number of observations for which it is in months. We also built an interval for the calendar year of quitting. Both intervals are constructed so as to be consistent: they do not overlap and the maximum calendar year for quitting or starting is 2001+5/12. We then took the middle of each interval to define our duration variables.

[8] Note that starting and ending dates of spells were not rounded to the nearest year.

[9] Whatever the cohort, more than two-third of lifetime smokers start to smoke between 14 and 20. For those individuals who were aged less than 20 in 2001, *PRICE1420* is set equal to the average price between the year they were 14 and the 2001.

[10] These figures were obtained by computing for every individuals the predicted probability of starting before age 18, and by simulating the change induced by a permanent 1% increase in prices (*i.e.* both *PRICE* and *PRICE 1420* rise by 1%).

[11] Since smoking has no short-term effects on health, it does not affect educationnal choices.

[12] Boltanski (1971) shows to what extent social proximity between physicians and patients eases the spread of healthy lifestyle habits in the more general post-war era context of the “medicalization of the lifestyle habits”.

[13] This may be true for European countries but not the United States, since inequality appears to have a negative effect on happiness in Europe only (Alesina, Di Tella et MacCulloch, 2001).