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Abstract

In this paper, we use US data from the Behavioral Risk Factor Surveillance System to examine unintended side-effects related to smoking bans, and cigarette prices, and taxes on health behaviors. Our findings show that smoking bans not only had positive direct effects on smoking but also induced healthier lifestyles: the bans significantly reduced drinking participation and consumption and promoted physical activity, with heterogeneous effects in certain socio-economic groups, whereas cigarette prices and taxes affected the health behaviors of disadvantaged population groups. Robustness analyses show that results do not change when we consider ever-smokers or control for unobservable state-specific time-varying confounders.

Keywords: Smoking bans, cigarette prices, health behaviors, instrumental variables.

JEL classification: I10, I12, I18

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1 Introduction

During the 1990s, increasing awareness of the negative effects of exposure to passive environmental tobacco smoke increased the need to adopt anti-smoking policies in the US. The most important instruments adopted by policy-makers to discourage smokers and prevent the harmful effects of passive smoking were increases in cigarette prices - and taxes - and the application of clean indoor air laws (CIALs) in a variety of public places, such as cafés and bars, restaurants, elevators, public meeting rooms, and in the workplace.

Anti-smoking policies have been widely adopted in the US, especially after the 1986 Surgeon General's report and the 1986 National Academy of Science/National Research Council's task force report on passive smoke, which highlighted how passive smoking was closely linked to higher rates of cancer and heart disease in non-smokers. Although anti-smoking measures were initially intended to protect non-smokers from the negative effects of passive smoking, they also proved to have beneficial effects in reducing smoking prevalence and cigarette consumption among smokers. This result was especially evident in the case of workplace smoking bans, due to the higher number of hours during which the restriction was imposed (Evans & Montgomery 1999).

However, beyond the direct effects on smoking reduction, the health economics literature has recently focused on other outcomes, which may have been indirectly affected by these interventions. The aspect most extensively studied is the prevalence of obesity (see Liu et al. (2010), Wildman & Hollingsworth (2012), Pieroni & Salmasi (2012) for the effects of smoking bans, and Gruber & Frakes (2006), Baum (2009), Courtemanche (2009), Adda & Cornaglia (2010), Wehby & Courtemanche (2012) for the effects of higher cigarette prices). The reason for this is that obesity has dramatically increased in the last few decades and has become a substantial risk factor for a number of severe and chronic diseases constituting main causes of death, including heart disease, stroke, some types of cancer, and Type 2 diabetes. The efforts exerted so far to identify the indirect effects of smoking control policies are therefore explained by the fact that the gains in terms of reduced mortality and medical expenditures may have been downscaled or even canceled out by unintended and unforeseen costs relating to overweight and obesity (Courtemanche 2009, Liu et al. 2010).

Although the prevalence of obesity may represent an important side-effect of anti-smoking policies, this is only part of the story: there may be other indirect effects, associated with similar diseases and negative consequences in terms of public health. Examples are alcohol consumption or physical exercise, which have received little attention in the literature but which should be considered when assessing overall policy effectiveness. We aim explicitly at analysing the indirect causal effects of smoking on other health behaviors, also in order to explain the costs and benefits generated by smoking control policies. Neglecting some of the side-effects gives only a partial picture and may lead to erroneous conclusions when evaluating anti-smoking interventions.

In the case of alcohol consumption, Pieroni et al. (2013), basing their model on the assumption that smoking and drinking are complementary goods (Dee 1999, Yörük & Yörük 2011, Crost & Guerrero 2012) and exploiting the 2005 Italian smoking ban, compared the drinking habits of smokers and non-smokers and found a significant reduction in alcohol consumption for quitters after the ban came into force. In addition, physical exercise is considered one of the possible channels through which quitting smoking may affect BMI and obesity. Individuals who reduce their smoking, after smoking ban enforcements, may be directed toward healthier life-styles, favoring physical exercise (Courtemanche 2009).

This paper aims at filling this gap by analysing the effects induced by the introduction of smoking bans and the impact of increased cigarette prices and taxes in the US on unexplored health outcomes, such as drinking habits and physical exercise. In addition, exploiting the exogenous variation induced by smoking bans on smoking habits, we also estimated the effect of smoking on alcohol consumption and physical exercise in causal terms. Given that omitted variables, affecting smoking habits and drinking or physical exercise choices at the same time, are likely to bias OLS estimates, we adopted an instrumental variable (IV) strategy, in which smoking bans are used as an instrument for smoking. We use data from 23 independent cross-sections of the Behavioral Risk Factor Surveillance System (BRFSS) for the period 1984-2006, a nationally representative survey of American adults over the age of 18. This survey includes information about respondents' drinking habits, physical exercise, health status and socio-demographic characteristics such as gender, race, occupation, education, and income, and information about the presence of smoking bans in public places or workplaces in the state of residence in a given year. For the smoking ban analysis, we used nine of the above-mentioned cross-sections, between 1998 and 2006, for which information about smoking restrictions was available at individual level. Instead, the entire dataset was used to analyse the effect of prices and taxes. We also conducted a series of robustness checks, to test whether including various types of state trends among the control variables affected our baseline results.

Our study makes three main contributions to the existing empirical literature. First, it provides estimates of the indirect effects of smoking bans on drinking and physical activity in the US. Our estimates indicate that the direct effects of the ban on the percentage of smokers were highly statistically significant and negative: the introduction of anti-smoking legislation in particular reduced smoking participation by about 33%, as Liu et al. (2010) also found. In addition, in the baseline model, smoking bans caused a decrease in the percentage of drinkers by 2 percentage points and a reduction in the number of drinks consumed (about 3 drinks per month). Anti-smoking legislation also induced more physical activity: in particular, the ban caused an increase in the number of people taking physical exercise by 2 percentage points. Second, we estimate the relationship between smoking and drinking or physical activity in a quasi-experimental setting. We find that a 1% increase in the prevalence of smokers leads to a statistically significant increase in the percentage of drinkers by 8.76 percentage points and a higher number of drinks consumed (12) per month. Regarding physical activity, our results indicate that a 1% increase in smokers' prevalence leads to a decrease of 9.49 points in the percentage of individuals who take exercise. These estimates show the unintended (and unforeseen) benefits of antismoking legislation in terms of alcohol consumption and physical exercise, which may be explained by a change in expected longevity or renewed interest in health (Courtemanche 2009). Third, we estimate the effect of cigarette prices (and taxes) on drinking and physical activity in the US, to verify whether the smoking ban results are policy-specific. We find that the price of cigarettes has no significant effect on drinking behavior, number of drinks, physical exercise or minutes of physical activity, except for a select group of the population, i.e. poorly educated and low-income individuals.

The paper is organized as follows. Section 2 presents a review of the literature on the main anti-smoking interventions adopted in the US during the last few decades and on their possible indirect effects on drinking and physical activity. Section 3 specifies our empirical approach based on an IV strategy to evaluate the effect of smoking on alcohol consumption and physical exercise in the case of smoking bans; a reduced-form model is used to estimate the effects of the price of cigarette and relative taxes on health behaviors. Section 4 describes the dataset used and the basic facts. Section 5 presents the main results and the robustness analysis. Section 6 concludes.

2 Literature review

2.1 Clean indoor air laws

Although isolated examples of policies restricting smoking have been recorded earlier, the 1973 law in Arizona was the first state intervention achieving smoke-free aims in public places. The reasons given for state intervention, thereafter flexibly applied during the 1970s in other US states, followed the recommendations of the Surgeon General's Report[1], which emphasized the adverse health effects of passive smoking on public health.

As demonstrated by several studies, this legislation not only protected non-smokers from the dangers of passive smoking, but also helped to prevent young people from starting smoking, reduced the number of cigarettes smoked, and encouraged some smokers to quit. One classic health economics paper analysing the effects of smoking bans was that of Chaloupka & Saffer (1992). These authors, like Evans et al. (1999), emphasized the result that, while prohibiting smoking at the workplace was effective in reducing prevalence and consumption, the effects were greatly reduced when restrictions were introduced only in public places. These results were also in line with findings in Australia and Canada (e.g., Fichtenberg & Glantz (2004)).

With the exception of Finland[2], European CIALs are relatively recent. In Europe, the literature on the effects of smoking bans in restaurants, bars and cafés cites controversial effects. For instance, Nagelhout et al. (2012) showed that (comprehensive) smoking bans in Ireland and England had positive effects on quitting, whereas (partial) bans had no effect in The Netherlands. Jones et al. (2011) did not find any significant effects of the smoking ban in England or Scotland; non-significant effects were also found in Germany by Anger et al. (2011). Kennedy et al. (2012) analysed the French smoking ban in hospitality venues, showing that the indoor smoking ban reduced smoking habits. Gallus et al. (2006), Federico et al. (2012), Pieroni et al. (2013), Pieroni & Salmasi (2012), evaluating

[1] US Department of Health and Human Services (1972).
[2] The Finnish Tobacco Control Act (TCA) was implemented in 1976.

the 2005 Italian law for smoke-free public places, estimated that smoking prevalence and consumption decreased significantly after the ban came into force.

2.2 Cigarette prices

A variety of studies have investigated the direct effects of the price of cigarettes on smoking, (see, for example, Chaloupka & Warner (2000) for a survey of the literature). These studies can be classified according to the type of data they use: there are in fact substantial numbers of papers which use aggregate data: Baltagi & Goel (1987), Peterson et al. (1992) compared states which increased cigarette taxes with ones in which taxes were not changed, finding a negative and significant price elasticity. Other studies focused on the relation between cigarette price and consumption in developing countries, (Chapman & Richardson 1990, Mao 1996, Xu et al. 1998, Van Walbeek 2001). However, results based on time series data were found to be extremely volatile, due to the high correlation between significant explanatory variables and price. Another disadvantage of these studies is that they can only provide estimates for the overall effect of price on cigarette consumption, neglecting potential heterogeneous effects on population subgroups of particular policy interest, such as young adults and some disadvantaged groups. Studies using individual-level data from large-scale surveys generally find similar results in terms of estimated price elasticities of demand for cigarettes. Individual-level data make the simultaneity between cigarette price and consumption less meaningful, since an individual's smoking decisions are presumed not to be able to affect the market price of cigarettes. The most significant works applying individual-level data to estimating the relationship between the price of cigarettes and the demand for them are those of Lewit et al. (1981), Lewit & Coate (1982), Grossman et al. (1983), Becker et al. (1991), Wasserman et al. (1991), Chaloupka et al. (1997). Adda & Cornaglia (2010) have also recently estimated the effects of smoking bans and cigarette price on passive smoking, and assessed indirect effects on children by exploiting a variety of data sources.

2.3 Side-effects of anti-smoking policies on health behaviors

As noted in the Introduction, the most extensively studied side-effect of anti-smoking legislation so far is the prevalence of obesity, (Gruber & Frakes 2006, Baum 2009, Liu et al. 2010, Wildman & Hollingsworth 2012, Pieroni & Salmasi 2012). Looking at the temporal correlation between the rise in obesity and anti-smoking campaigns in the US, and in view of the medical evidence about the role of smoking as metabolic determinant, much of the health economics literature has estimated the causal effect of smoking on obesity and BMI by applying several empirical strategies.

Additional side-effects, apart from obesity, may arise because anti-smoking campaigns may have affected expected longevity in general or interest in personal health (Courtemanche 2009), leading to healthier behaviors, also in terms of drinking and taking exercise.

There are several studies examining the relation between drinking and smoking, mostly in the medical and psychological literature, although some examples also appear in health economics. In the psychological literature, for instance, the correlation between alcohol and tobacco use is explained by a *cross-drug priming effect*: smoking may increase the craving for alcohol (Rohsenow et al. 1997). Epstein et al. (2007) and King & Epstein (2005) also found a positive correlation between the quantity of alcohol consumed and the urge to smoke; other authors, using ecological momentary assessment (EMA), have also reported that drinking alcohol is associated with more frequent and greater self-reported urges to smoke (Delfino et al. 2001, Piasecki et al. 2008). Drinking has been proved to be complementary to smoking also in the health economics literature. For instance Dee (1999), looking at young adults and exploiting the minimum legal drinking age ($MLDA$), found that drinking roughly doubles the mean probability of smoking participation, highlighting the fact that *public health efforts aimed at reducing the prevalence of teen smoking and drinking may generate important and unintended benefits* (Dee 1999, p. 770). The minimum legal drinking age was also used by Yörük & Yörük (2011) and Crost & Guerrero (2012) to evaluate the spillover effects of alcohol drinking on marijuana use, finding some evidence about the negative effect of alcohol on the latter and therefore indicating some degree of substitutability between them. Again related to alcohol consumption and smoking, but more on quitting smoking - when the association between the two becomes more important (Businelle et al. 2013) - Picone & Sloan (2003) found that those who quit smoking began to consume less alcohol; however, there are other studies (e.g., Brady & Sonne (1999), Frone (2008)) which support the *tension reduction hypothesis*: quitting smoking often implies a considerable amount of stress, which may induce individuals to use alcohol to cope with cessation stress (Sayette 1999). Which effect prevails between these competing hypotheses is an empirical matter. In the health economics literature, to our knowledge, the only paper which exploits smoking bans to estimate the effect of smoking on drinking in causal terms is that of Pieroni et al. (2013). These authors, examining the CIALs introduced in Italy, estimated the indirect effects of the smoking ban on alcohol consumption, finding that the percentage of habitual drinkers of alcoholic beverages, typically consumed outside the home, decreased after the ban was introduced, suggesting complementarity rather than support to the *tension reduction hypothesis*, at least in Italy.

In another paper, Courtemanche (2009), examined alternative health behaviors, apart from drinking, which may have been influenced by smoking. The author analyses the effect of cigarette price on BMI and reconciles results with existing findings by examining exercise and food consumption (number of grams of fat consumed per day; number of times fruit and vegetables are consumed per week). According to the author, reducing smoking may have been influenced by psychological phenomena, eating/drinking behaviors and exercise habits. People who are exogenously induced to smoke less (or quit altogether) may experience a renewed sense of interest in their health, leading them to focus on other things, such as a healthier diet and exercise (Courtemanche 2009). In addition, people who are able to overcome their smoking addiction may gain in self-confidence and develop healthier habits (Sweet 2000).

Among possible spillovers of anti-smoking legislation, there are not only other health behaviors, e.g. drinking, and physical exercise, but also less straightforward related consequences driven by consumption behaviors. Adams & Cotti (2008) looked at how geographical variation in local and state smoke-free bar laws in the US explains car accidents involving alcohol, identifying as one cause the fact that smokers drive longer distances to bars, or public places in general, where smoking is allowed.

In the literature on smoking and obesity, a recent paper (Dragone et al. 2013) also exploited heterogeneity in the policies implemented, to ascertain whether instruments, (i.e., taxes or smoking bans) can lead to different consequences in terms of eating habits and obesity.

3 Empirical strategy

In this paper, we aimed at estimating the effects of anti-smoking legislation on unexplored health outcomes, such as drinking habits and physical exercise. We used two identification strategies, one exploiting the introduction of smoking bans in the workplace or in public places in the US, and the other following real cigarette prices and taxes.

To estimate the effect of smoking bans on health behaviors, we consider the following standard specification:

$$HB_{it} = \alpha_0 + \alpha_1 S_{it} + \sum_{j=1}^{J} \delta_j X_{jit} + \epsilon_{it} \tag{1}$$

where HB_{it} describes three health outcomes, measuring alcohol participation ($HB_{it} = 1$ if individual i at time t had at least one alcoholic drink during the last month), alcohol consumption ($HB_{it} =$ number of drinks consumed during the last month for individual i at time t) and participation in physical activity ($HB_{it} = 1$ if individual i at time t participated in any physical activity during the last month). S_{it} identifies individual smoking status, and X_{jit} is a vector of covariates at individual, year or state levels (for detailed descriptive statistics, see Table 1). Moreover, when we estimate the effect of smoking for each of the health behaviors analysed, we include the remaining ones among the control variables, as drinking habits (physical exercise) may be correlated with smoking and physical exercise levels (drinking habits).

Our interest focused on estimating α_1, the coefficient capturing the effect of S_{it} on HB_{it}. A direct estimate through OLS would be biased by the presence of unobserved heterogeneity in individuals' choices influencing drinking habits and physical exercise as well as smoking status. In other words, quitters (or individuals who reduce smoking) are more likely to adopt other behaviors such as drinking less or taking physical exercise more frequently. These positive side-effects are explained by psychological phenomena: people who are exogenously forced to smoke less (or quit altogether) may experience a renewed sense of interest in their health, leading them to target other areas, such as drinking, eating and exercise (Courtemanche 2009). In addition, a person who is able to overcome smoking addiction may gain self-confidence and develop healthier habits (Sweet 2000). It is not even clear whether cigarette smoking affects health behaviors or vice versa. In fact, it may also be argued that individuals who take physical exercise more often or drink less are more prone to reducing smoking or quitting, so that reverse causality is also likely to be an important issue when estimating the causal effect of smoking on health behaviors.

To overcome these endogeneity problems, we use an IV estimator, in which smoking bans are used to instrument individual smoking habits. In order to achieve identification, we include a dummy variable (SB) in the first-stage equations of smoking and health behavior indicators, which records an exogenous change in individual smoking habits. We define the smoking ban dummy variable as 1 for individuals working in places with active smoking bans during the interview year, and 0 otherwise. The reduced-form specifications for smoking variables and health behaviors are:

$$HB_{it} = \beta_0 + \beta_1 SB_{it} + \sum_{j=1}^{J} \omega_j^1 X_{jit} + u_{it} \tag{2}$$

and

$$S_{it} = \delta_0 + \delta_1 SB_{it} + \sum_{j=1}^{J} \omega_j^2 X_{jit} + v_{it}. \tag{3}$$

From equations (2) and (3) we can estimate the direct effects of smoking bans on drinking habits and physical exercise. These results can then be used in a structural model to derive causal estimates of S_{it} on HB_{it}. Formally, this is given by:

$$HB_{it} = \theta_0 + \theta_1 S_{it} \sum_{j=1}^{J} \omega_j X_{jit} + v_{it}, \tag{4}$$

where the IV estimate of the effect of smoking on each health behavior indicator is expressed in equation (4) as the ratio of the reduced-form coefficients in equations (2) and (3), $\theta_1 = \beta_1/\delta_1$. This strategy identifies the average causal effect for those individuals who modify their smoking choices, because they react to the instrument (i.e., the smoking ban) and this can yield causal estimates from the local average treatment effect (LATE)[3].

Instead, concerning the effect of real cigarette retail prices and taxes, we examine the following specification:

[3]See Imbens & Angrist (1994). For an application, see Angrist (1995).

$$HB_{it} = \gamma_0 + \gamma_1 ASP_{st} + \sum_{j=1}^{J} \Psi_j X_{jit} + \epsilon_{it} \tag{5}$$

where HB_{it} now describes four health outcomes, again measuring alcohol participation and consumption, physical activity participation and intensity (HB_{it} = minutes of physical exercise per day for individual i at time t). The last outcome variable can be analysed only in this model because the information on physical exercise intensity was not available in the smoking ban sample. ASP_{st} is a varaiable that represents the anti-smoking policy analysed (i.e., real cigarette retail price and taxes) which vary at state and year level. We follow the specification adopted by Wehby & Courtemanche (2012) to estimate the effect of cigarette price and taxes on BMI and include a six-year moving average, spanning t to *t-5* for cigarette price and taxes, a vector X_{jit} of demographic controls, and state and year fixed effects (for detailed descriptive statistics, see Table 1). Also in this case, when we estimate the effect of smoking for each of the health behaviors analysed, we include the remaining ones among the control variables.

Section 5 also presents a robustness analysis controlling for the presence of various types of state trends, as in Gruber & Frakes (2006), Courtemanche (2009), Liu et al. (2010). In particular, we estimate various specifications including various types of state-specific trends to take into account unobservable variables at state level, which may affect our baseline estimates. We also test the robustness of our results by estimating the same models on a subsample composed of ever-smokers only.

4 Data and descriptives

Three main datasets are available to study the effectiveness of anti-smoking policies on health behaviors: BRFSS and NHANES, which contain cross-sectional information, and NLSY, which provides longitudinal data. In this paper, we use the BRFSS, which contains the most comprehensive data on smoking behavior in the US, used to monitor smoking trends at state level (Adda & Cornaglia 2010), and also because of its large sample size. As already emphasized in the literature, the observations in this dataset counts millions of individuals, as opposed to the tens-of-thousands in NHANES and NLSY.

In our case, smoking bans were recorded at individual level: this detailed information and large sample size were preferred in comparison with datasets with a lower number of observations and in which identification relies on aggregate-level variables such as smoking bans introduced at state level. Although NLSY and NHANES do have advantages the literature (e.g., Courtemanche (2009)) shows, for instance, that the estimated average effects of cigarette price on BMI were similar with NLSY and BRFSS, with gains in terms of precision when the latter was used.

Interviews were conducted via telephone for a random sample selected by US state health departments and the Center for Disease Control. The sample was composed of 30,000 observations on average per year. Individuals were asked about their state of health and risky behaviors, especially smoking (whether the person was currently a smoker or had quitted), exercise and drinking, but socio-demographic characteristics, such as age, race, gender, education and income were also used, to examine the heterogeneity in smoking bans and the effects of cigarette price and tax. We used data from 1998 to 2006 to investigate the effects of smoking bans in which only employed individuals were considered; data from 1984 to 2006 were used to assess the effect of price and tax. We therefore pooled nine cross-sections, in the first case due to the availability of smoking ban information, and 23 cross-sections in the second.

Information about prices were retrieved from ''The Tax Burden on Tobacco''[4] (Orzechowski & Walker 2006). We adjusted price for inflation by means of the Consumer Price Index for all urban consumers from the Bureau of Labor Statistics. ''The Tax Burden on Tobacco'' also provides monthly state cigarette excise tax rates, which we used instead of price for a robustness check.

Table 1 lists the sample characteristics: current smokers total 24% in the smoking ban sample and 23% in the price and tax sample. The prevalence of drinkers in both samples was 53%, and on average they consumed 11 drinks per month. About 75% of the individuals in the smoking ban sample had taken physical exercise during the previous month, whereas the figure was slightly lower in the price and tax sample. Table 1 also lists the socio-demographic characteristics of both samples in our empirical analysis. The most noticeable differences were found regarding employment status[5].

[4]The report lists the average price, across single-pack cartons, and vending machine sales, for a pack of 20 cigarettes (Chaloupka & Grossman 1996). Prices include state and federal excise taxes but not sales taxes. After 1989, The Tax Burden on Tobacco reported prices both including and excluding generic brands. We follow Chou et al. (2004) and use the series excluding generics to allow for greater comparability across the sample period.

[5]In the smoking ban sample unemployed and retired individuals were not considered.

Figure 1 shows that, in the smoking ban sample, the percentage of smokers is always higher for individuals working in places in which a smoking ban is in place, compared with smoke-free workplaces, for each socio-economic group considered. Instead, Figure 2 shows the same comparison, considering the percentage of drinkers in varying socio-demographic groups: here, the picture is less clear than before; according to some characteristics, e.g. race, income, and education, the prevalence of drinkers is lower in workplaces with smoking bans, indicating complementarities between smoking and drinking, although this result is no longer clear-cut when we focus on age or gender. Therefore, in Figure 3 we compared a measure of drinking intensity, which is more informative about unhealthy behaviors compared with drinking *per se*. This yielded a much clearer picture: the number of alcoholic drinks was always higher in smoke-free areas, highlighting the complementarity between the sin goods. Lastly, Figure 4 shows data on physical activity: according to each socio-demographic characteristic, the percentage of individuals taking physical exercise in the previous month was higher in workplaces with smoking restrictions.

We see evidence in the price and tax sample of a correlation between variations in prices and in our outcomes of interest. Figure 5 shows how the median[6] percentage yearly variation in drinkers' prevalence by state is associated with the the median percentage yearly variation in real cigarette prices according to socio-demographic characteristics, i.e., gender, age, education, race, income, and employment status. We see that the picture is less clear when compared with Figure 2, in which smoking bans are examined, but in some cases the fitted line has a negative slope. Looking at the median percentage yearly variation in the number of alcoholic drinks in Figure 6, for poorly educated, black, and middle-aged individuals, the positive median yearly variations in prices are associated with reductions in the number of drinks. In particular, the larger the increase in prices, the greater the reduction in the number of drinks. Figures 7 and 8 show the same graphical analysis for participation in physical activity and minutes of training. Physical activity participation (Figure 7) shows a positive association with median percentage yearly variations in cigarette prices; a slightly less clear direction appears in Figure 8.

[6] The median is used to mitigate the influence of outliers.

Table 1: Descriptive statistics

		Smoking ban sample				Cigarette retail price/tax sample			
Variable	**Modality**	**Period**	**No. of observations**	**%**	**Mean**	**Period**	**No. of observations**	**%**	**Mean**
					Outcome variables				
Smoking now		1998-2006	337,449	0.24		1984-2006	2,837,980	0.23	
Drinking now		1998-2006	303,438	0.53		1984-2006	2,474,001	0.53	
No. of drinks in past month		1998-2006	299,902		10.77	1984-2006	2,427,899		11.04
Any physical activities in past month		1998-2006	337,992	0.75		1984-2006	2,843,285	0.64	
Minutes of daily physical exercise	-	-	-		-	1984-2000	678,646		43.41
					Control variables				
Gender	Male	1998-2006	338,173	0.38		1984-2006	2,846,231	0.45	
	Female	1998-2006		0.62		1984-2006		0.55	
Age	18-24	1998-2006	334,172	0.07		1984-2006	2,791,587	0.08	
	25-34	1998-2006		0.21		1984-2006		0.17	
	35-44	1998-2006		0.28		1984-2006		0.21	
	45-54	1998-2006		0.28		1984-2006		0.19	
	55-64	1998-2006		0.16		1984-2006		0.15	
	65+	-	-	-		1984-2006		0.2	
Race	White	1998-2006	336,217	0.81		1984-2006	2,829,636	0.82	
	Black	1998-2006		0.09		1984-2006		0.08	
	Hispanic	1998-2006		0.06		1984-2006		0.05	
	Other race	1998-2006		0.04		1984-2006		0.05	
Education	Less than high school	1998-2006	337,965	0.05		1984-2006	2,733,790	0.17	
	High school	1998-2006		0.28		1984-2006		0.28	
	Some college training	1998-2006		0.28		1984-2006		0.24	
	College degree	1998-2006		0.4		1984-2006		0.31	
Employment	Employed	1998-2006	338,173	0.88		1984-2006	2,720,768	0.57	
	Self-employed	1998-2006		0.12		1984-2006		0.11	
	Unemployed	-	-	-		1984-2006		0.11	
	Retired	-	-	-		1984-2006		0.21	
Household income	$0-$24,999	1998-2006	310,749	0.19		1984-2006	2,467,136	0.37	
	$25,000-$34,999	1998-2006		0.14		1984-2006		0.16	
	$35,000-$49,999	1998-2006		0.2		1984-2006		0.18	
	$50,000 or more	1998-2006		0.47		1984-2006		0.29	
Marital status	Never married	1998-2006	328,112	0.18		1984-2006	2,774,023	0.18	
	Married	1998-2006		0.61		1984-2006		0.54	
	Divorced, widowed or separated	1998-2006		0.22		1984-2006		0.28	
No. of children		1998-2006	337,788		0.83	1984-2006	2,400,039		0.65
Health status	Good, very good or excellent	1998-2006	338,173	0.92		1984-2006	2,846,231	0.87	
	Fair or poor	1998-2006	308890	0.08		1984-2006		0.13	
No. of days physical health not good in past month		1998-2006	308,307		2.13	1984-2006	2,246,475		3.61
No. of days mental health not good in past month		1998-2006	308,307	3.07		1984-2006	2,248,704		3.23
Health insurance coverage	Yes	1998-2006	337,695	0.88		1984-2006	2,559,962		0.88
	No	1998-2006		0.12		1984-2006			0.12
Smoking ban	Yes	1998-2006	338,173	0.74		-	-	-	
	No	1998-2006		0.26		-	-	-	
Retail price of cigarettes	-	-			1984-2006	2,846,232		$2.73	
Cigarette taxes	-	-			1984-2006	2,846,232		$0.43	

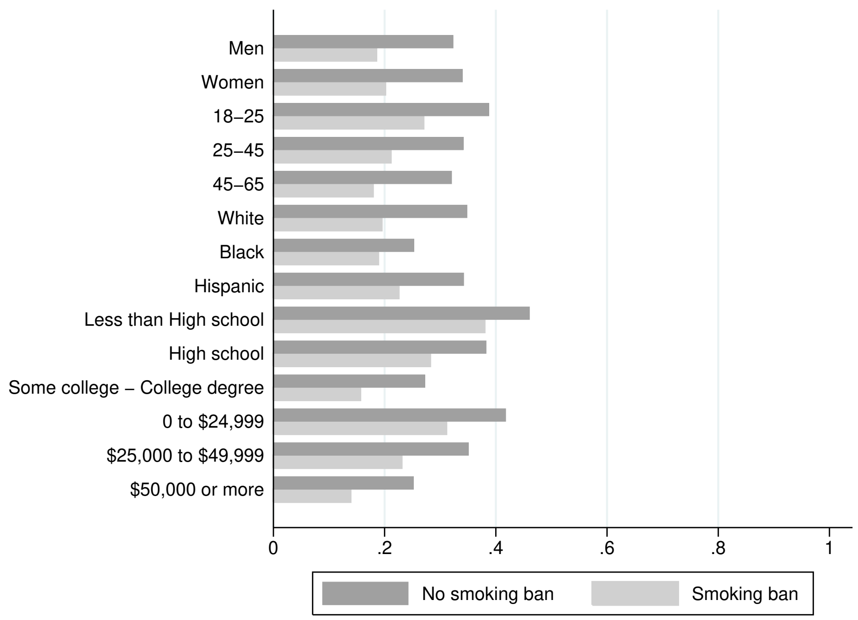

Figure 1: Percentage of smokers by smoking ban.

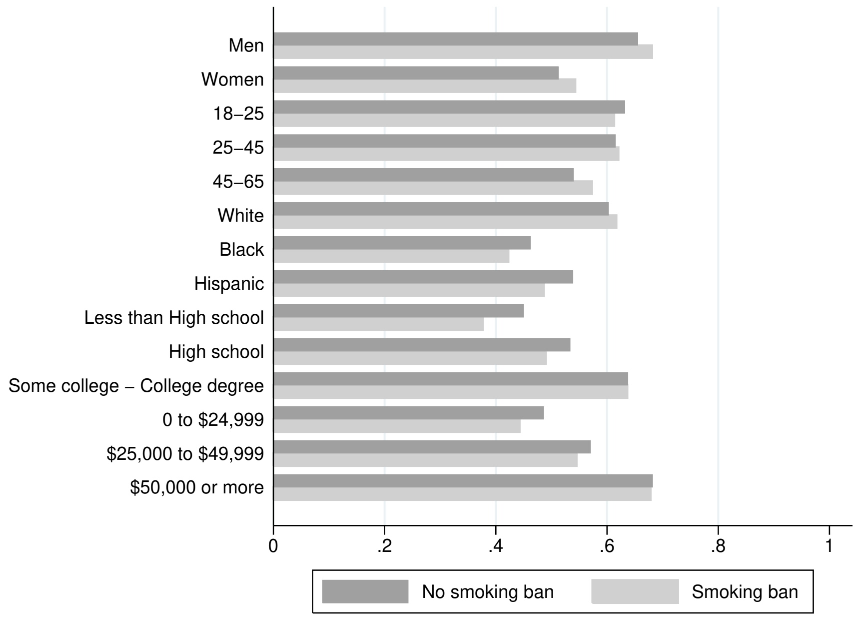

Figure 2: Percentage of drinkers by smoking ban.

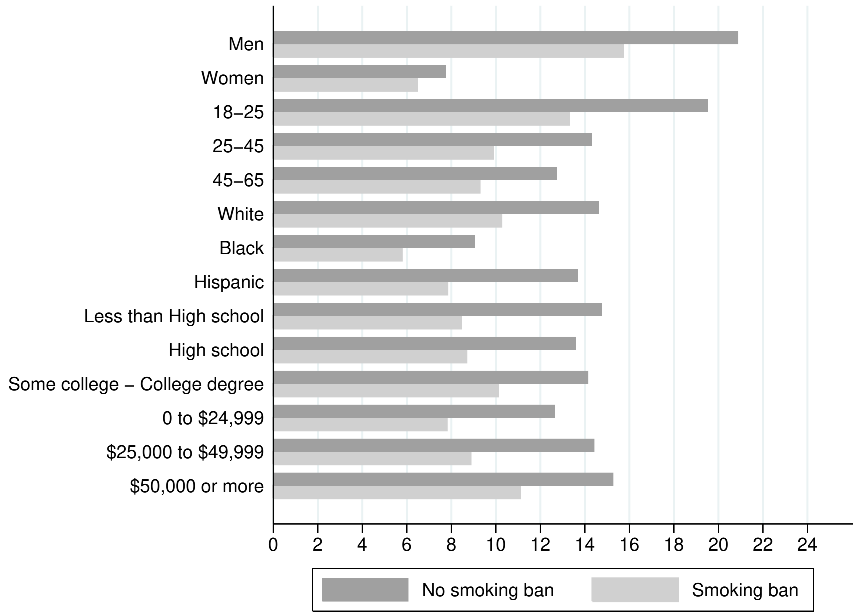

Figure 3: Number of drinks per month by smoking ban.

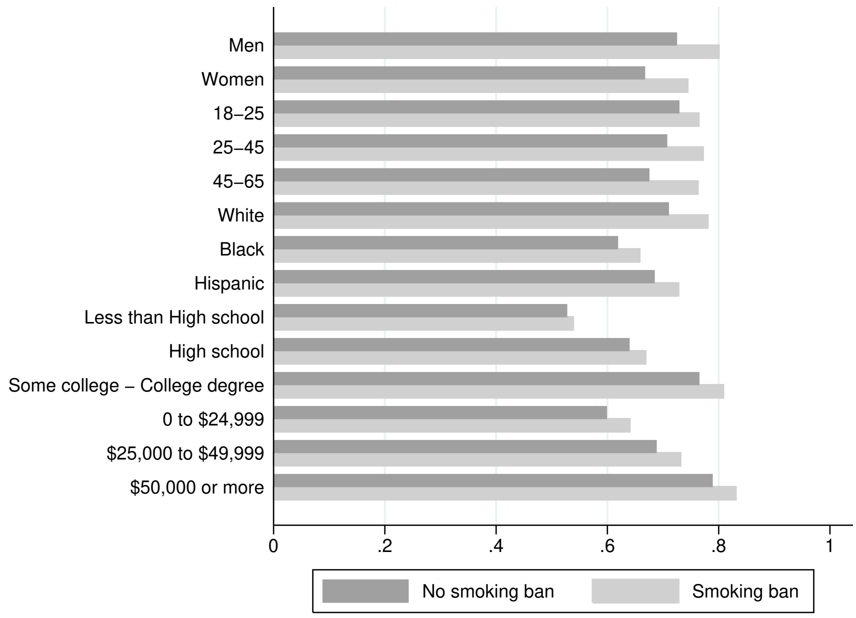

Figure 4: Any physical activity during previous month by smoking ban.

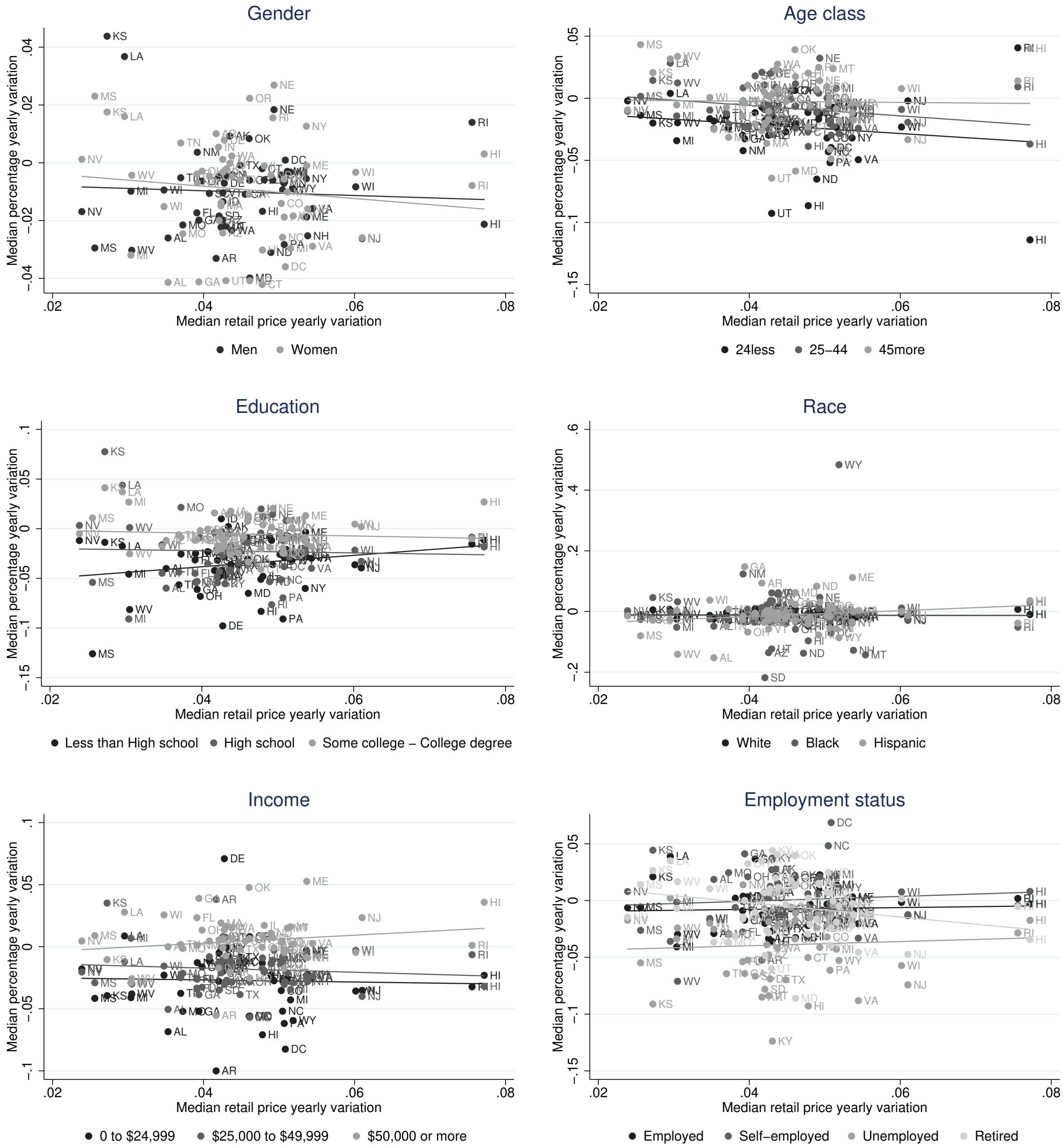

Figure 5: Percentage of drinkers - median yearly variations (1984-2006) vs. real cigarette retail price - median yearly variations (1984-2006), by socio-economic groups.

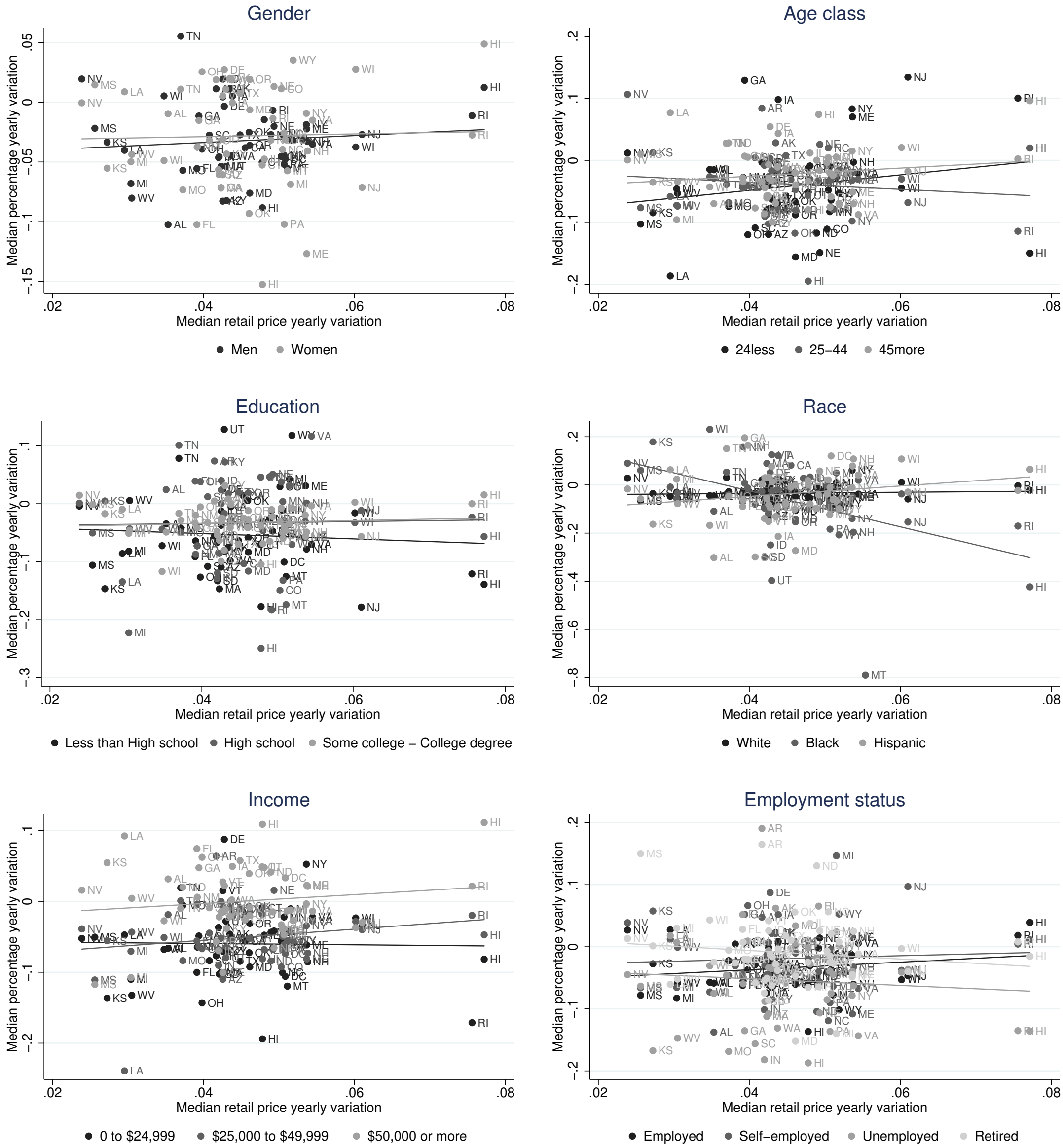

Figure 6: Number of drinks per month - median yearly variations (1984-2006) vs. real cigarette retail price - median yearly variations (1984-2006), by socio-economic groups.

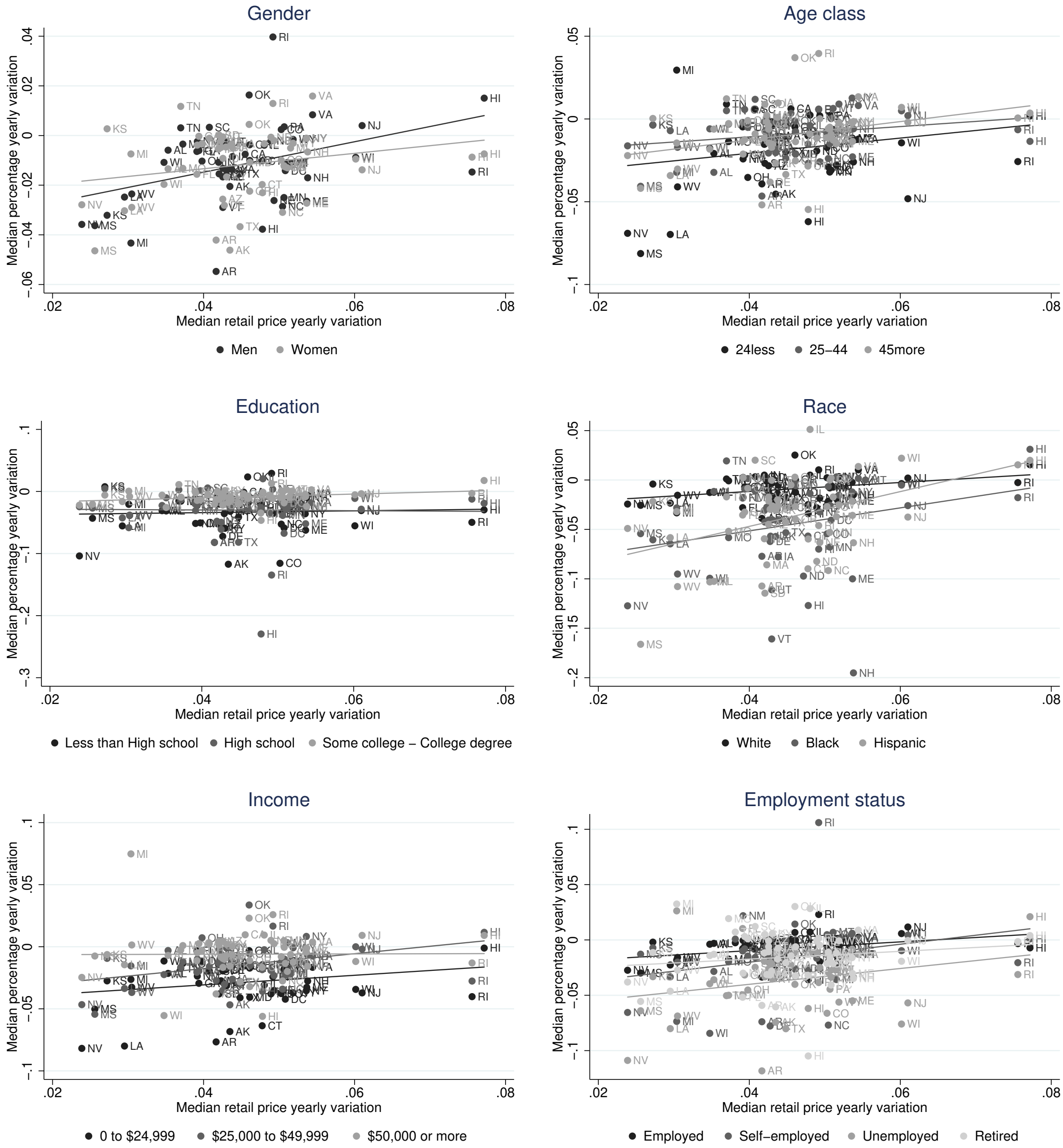

Figure 7: Any physical activity in previous month - median yearly variations (1984-2006) vs. real cigarette retail price - median yearly variations (1984-2006), by socio-economic groups.

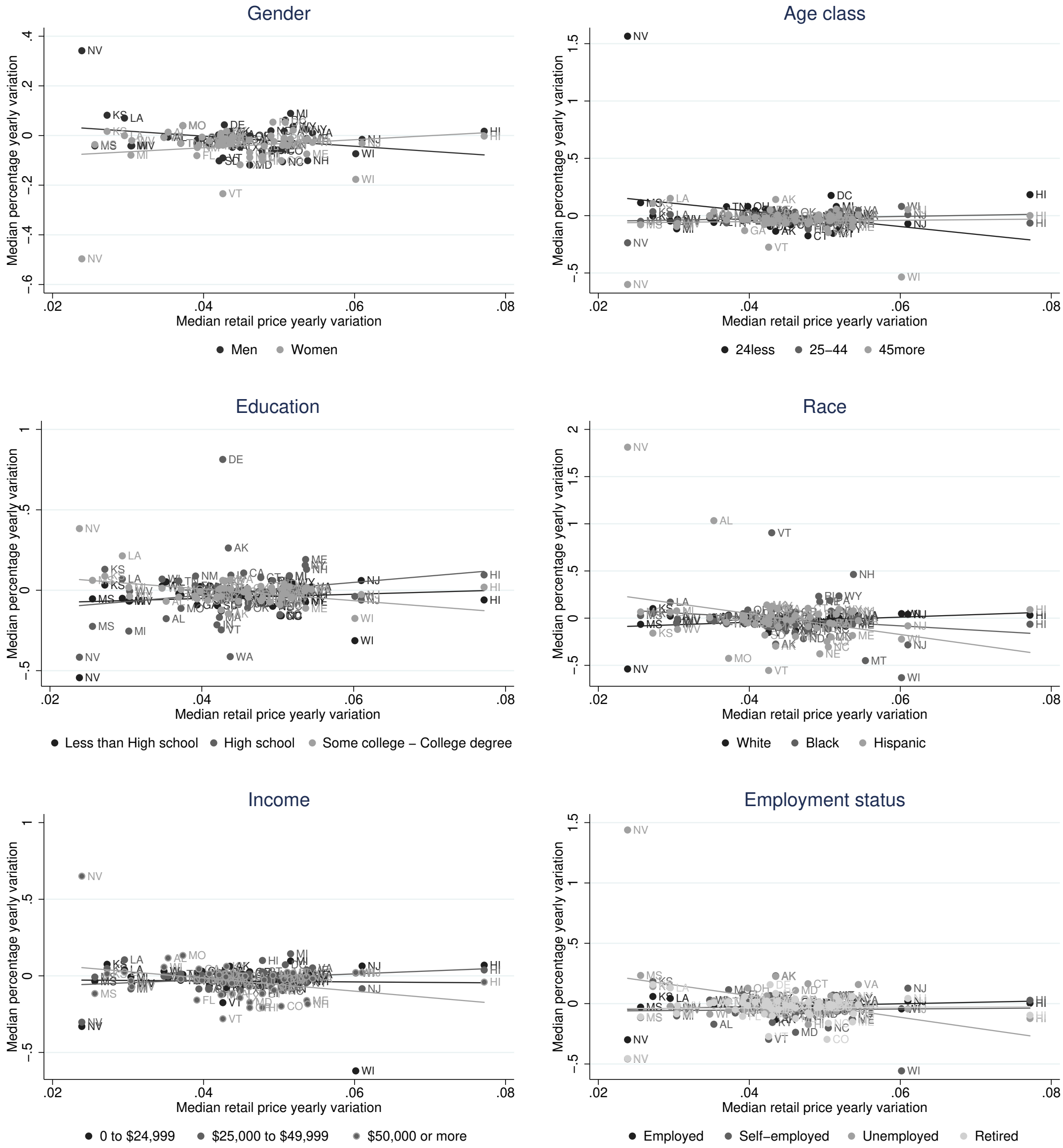

Figure 8: Minutes of physical exercise per day - median yearly variations (1984-2006) vs. real cigarette retail price - median yearly variations (1984-2006), by socio-economic groups.

5 Results

5.1 Effect of smoking bans on health behaviors

Table 2 shows the causal effect of smoking bans for our baseline model (see, equations 2-4), which controls for standard socio-demographics, time and state fixed effects, on the following outcomes: percentage of smokers, percentage of drinkers, number of drinks per month, and percentage of individuals who practised physical activity during the previous month.

In column 1 of Table 2, we see that the effect of the ban on the percentage of smokers is highly statistically significant and negative, meaning that the introduction of anti-smoking legislation reduced smokers' prevalence among employed individuals by 7.76 percentage points (SE[7] 0.003). Given a smoking rate in the overall sample of 23.6%, smoking participation after the ban fell by 32.88% (i.e., 7.76/23.6). This result is in line with those of Liu et al. (2010) and also shows that the instrument used here is significantly correlated with smoking.

Columns 2 and 3 of Table 2 show estimates related to the percentage of drinkers. Column 2 shows that the smoking ban effect is statistically significant and negative, causing a reduction of 2.02 percentage points (SE 0.002) of drinkers' prevalence. Column 3 shows that smoking reduces the percentage of drinkers by 8.76 percentage points (26.64×32.88). These initial results highlight the fact that, when accounting for endogeneity by means of bans, smoking is found to be complementary to drinking, as reported by Pieroni et al. (2013).

Columns 4 and 5 of Table 2 show estimates related to the number of drinks per month. Focusing on the reduced form (column 4), the smoking ban shows a highly statistically significant effect on the quantity of alcohol consumed per month, causing a reduction of 2.76 units (SE 0.192) in the number of drinks. As smoking bans reduced smoking participation by about 33% and the effect of smoking on the number of drinks is 36.50 (SE 2.998), the implied effect of smoking on the number of drinks should be about 12 units per month ($36.50 \times 32.88\%$), on average 3 drinks per week.

The last two columns of Table 2 focus on physical activity. Column 6 shows the reduced-form estimates of the smoking ban effect on the percentage of individuals who

[7] Standard errors are clustered at the state level.

exercised during the previous month: results indicate how anti-smoking legislation has a positive and highly statistically significant effect on physical exercise. In particular, it causes an increase in the percentage of people taking physical exercise by 2.07 percentage points (SE 0.002). In the last column, smoking reduces the percentage of individuals who exercise by 9.49 percentage points (28.89 × 32.88). Table 2 also lists the Angrist-Pischke tests of instrument validity from first-stage regressions, clearly indicating that our instrument is not weak in any of the estimated models.

Our initial set of results indicates that anti-smoking legislation, enforced in terms of smoking bans, had unintended (and unforeseen) benefits in terms of drinking and exercising, perhaps due to psychological phenomena such as a renewed sense of interest in better health (Courtemanche 2009).

We were also interested in understanding the heterogeneity of the smoking ban effects on health behaviors in several socio-economic groups. Table 3 lists estimates of the causal effect of smoking on the health outcomes of interest by gender, age class, ethnicity, education and income class. The upper panel of Table 3 shows that the effect is not statistically different between women and men, since the confidence intervals clearly overlap for each outcome except for alcohol consumption intensity - i.e., the number of drinks per month - in which structural estimates were higher for men (57.70; SE 5.714) than for women (19.20; SE 2.171).

Columns 2, 3 and 4 of Table 3 focus respectively on age, ethnicity, and education (less than high school, high school, and some college training or a college diploma). Significant differences were found in terms of participation in physical exercise between individuals younger and older than 25. The effect was stronger for individuals under the age of 25 (-0.1380 SE 0.046) and similar for those over 25, being respectively -0.3668 (SE 0.062) for those aged 25-45 years and -0.3859 (SE 0.056) for those aged 45-65 years. The effects of smoking, due to the introduction of smoking bans on health behaviors do not show heterogeneity according to ethnicity or education.

Concerning income, we provide estimates for three categories: individuals with income between $0 and $25,000 per year, $25,000 and $50,000 or $ 50,000 and over, the classification proposed by Wehby & Courtemanche (2012). Also in this case, we do not find any statistically significant differences when looking at confidence intervals.

Table 2: Effect of smoking on drinking (various measures) and physical activity. Baseline model

	% of smokers	% of drinkers		No. of drinks per month		Physical activity per month	
	Smoking (reduced form)	Drinking (reduced form)	Drinking (structural form)	Drinking (reduced form)	Drinking (structural form)	Physical activity (reduced form)	Physical activity (structural form)
Smoking ban	-0.0776***	-0.0202***		-2.7626***		0.0207***	
	(0.003)	(0.002)		(0.192)		(0.002)	
Percentage of smokers			0.2664***		36.4986***		-0.2889***
			(0.029)		(2.998)		(0.029)
Constant	0.5979***	0.5253***	0.3414***	26.8954***	5.5630***	0.6119***	0.7646***
	(0.016)	(0.012)	(0.021)	(1.096)	(1.440)	(0.016)	(0.015)
Observations	261,222	232,696	232,696	230,440	230,440	230,440	230,440
Angrist-Pischke test of excluded instruments			434.68		360.98		698.98

*Notes: Standard errors in round brackets are clustered at the state level. Significant levels: p-value *** $\leq$ 0.01, ** $\leq$ 0.05, * $\leq$ 0.1. Each specification includes state and year dummies.*

Table 3: Effect of smoking on drinking (various measures) and physical activity, by socio-economic status.

	% of drinkers	No. of drinks per month	Physical activity per month
		Gender	
Men	0.2075***	57.7029***	-0.4019***
	(0.068)	(5.714)	(0.066)
Women	0.2175***	19.2026***	-0.3147***
	(0.070)	(2.171)	(0.034)
		Age	
18-25	0.4058***	44.4501***	-0.1380***
	(0.102)	(6.027)	(0.046)
25-45	0.2787***	40.6356***	-0.3668***
	(0.087)	(4.523)	(0.062)
45-65	0.1826***	30.8656***	-0.3859***
	(0.064)	(4.559)	(0.056)
		Ethnicity	
White	0.1774***	31.6105***	-0.3303***
	(0.066)	(3.538)	(0.042)
Black	0.8596***	69.2402***	-0.5328*
	(0.257)	(17.531)	(0.321)
Hispanic	0.6222***	55.4517***	-0.3760**
	(0.155)	(12.010)	(0.151)
		Education	
Less than high school	0.6179***	59.6120***	-0.3805***
	(0.152)	(11.062)	(0.142)
High school	0.2762***	32.3597***	-0.4116***
	(0.079)	(4.553)	(0.060)
Some college training - College diploma	0.1644**	35.3959***	-0.3363***
	(0.071)	(3.925)	(0.058)
		Income	
$0 - $24,999	0.4044***	37.9383***	-0.4187***
	(0.069)	(5.306)	(0.072)
$25,000 - $49,999	0.2237***	36.5525***	-0.3337***
	(0.058)	(3.650)	(0.062)
$50,000 or over	0.1449	33.7075***	-0.3315***
	(0.094)	(4.676)	(0.047)

*Notes: Standard errors in round brackets are clustered at the state level. Significant levels: p-value *** $\leq$ 0.01, ** $\leq$ 0.05, * $\leq$ 0.1. Each specification includes state and year dummies.*

5.2 Effect of cigarette prices on health behaviors

This subsection presents estimates of the effect of smoking on health behaviors according to the price of cigarettes rather than smoking bans to ascertain whether results are policy-specific. Both the anti-smoking interventions considered (i.e., bans and price) change the incentives to smoke through different channels.

In addition to the outcomes already described, for a smaller sample we use a measure of physical activity intensity (i.e., minutes of physical exercise per day, data available from 1984 to 2000). Table 4 shows that there is no evidence of a significant price effect on drinking prevalence, number of drinks, exercising or minutes of physical activity per day. However, in order to verify whether the whole sample masks heterogeneous effects in selected groups of the population.

Table 5 lists estimates stratified by gender, age, ethnicity, education, income, and employment status. The significant effects of cigarette price are found in the health behaviors of poorly educated and low-income individuals. An increase of $1 in the real price of cigarettes reduces the number of drinks per month by 3.25 units (SE 1.167) among poorly educated individuals, and by about 1.74 units (SE 0.811) among low-income groups. Significant effects are also found for intensity of physical activity: again, low-educated individuals show statistically significant increases in terms of minutes of physical exercise, i.e., an increase of $1 in the real cigarette price increases the time devoted to physical activity in one day by about 26 minutes for low-educated individuals. The self-employed also show a statistically significant coefficient: a $1 increase in cigarette price leads to about 18 more minutes of physical exercise.

Appendices A.1-A.2 also list estimates of the baseline model, from equation (5), for the whole sample and by socio-economic group, with excise tax as a robustness check. The results are substantially the same; statistically significant coefficients are mostly found for low-educated and low-income individuals or the self-employed.

Table 4: Effect of cigarette price on drinking (various measures) and physical activity (various measures).

	Effect of prices on health behaviors			
	% of drinkers	No. of drinks per month	Physical activity per month	Mins. of physical exercise per day
Retail price	0.0098	-0.4862	0.0086	4.9288
	(0.019)	(0.664)	(0.041)	(6.178)
Constant	0.5944***	29.5451***	0.6285***	64.9001***
	(0.017)	(0.932)	(0.045)	(5.982)
Observations	1,879,026	1,847,390	1,879,026	286,013
R-squared	0.13	0.05	0.32	0.03
Adj. R-squared	0.13	0.05	0.32	0.03

*Notes: Standard errors in round brackets are clustered at the state level. Significant levels: p-value *** $\leq$ 0.01, ** $\leq$ 0.05, * $\leq$ 0.1. Each specification includes state and year dummies.*

Table 5: Effect of cigarette price on drinking (various measures) and physical activity (various measures), by socio-economic status.

	Effect of prices on health behaviors			
	% of drinkers	No. of drinks per month	Physical activity per month	Mins. of physical exercise per day
		Gender		
Men	0.0103	-1.2085	0.0020	7.5712
	(0.018)	(1.075)	(0.040)	(7.784)
Women	0.0085	0.222	0.0141	2.9067
	(0.020)	(0.345)	(0.042)	(5.210)
		Age		
18-25	0.0409*	0.5395	-0.0206	5.0455
	(0.023)	(0.924)	(0.035)	(6.413)
25-45	0.0025	-0.9362	0.0208	5.1418
	(0.020)	(0.994)	(0.049)	(7.774)
45-65	-0.0128	-1.4402*	0.0213	1.5992
	(0.019)	(0.743)	(0.049)	(8.413)
65 +	-0.0291	-1.7592*	0.0099	11.7394
	(0.022)	(0.877)	(0.034)	(10.568)
		Race		
White	0.0073	-0.3857	0.0119	7.2010
	(0.018)	(0.622)	(0.043)	(6.827)
Black	0.0279	0.2475	-0.0076	9.2148
	(0.027)	(0.782)	(0.045)	(9.435)
Hispanic	0.0222	-0.2648	-0.0331	5.8878
	(0.041)	(1.782)	(0.049)	(13.911)
		Education		
Less than high school	-0.0432	-3.2518***	-0.0286	25.6182**
	(0.027)	(1.167)	(0.032)	(10.658)
High school	0.0052	-0.1303	0.0042	-3.6378
	(0.017)	(0.770)	(0.068)	(16.166)
Some college training - College diploma	0.0228	0.4343	0.0291	3.1665
	(0.016)	(0.597)	(0.072)	(6.974)
		Income		
$0 - $24,999	-0.0029	-1.7433**	-0.0110	10.1135
	(0.019)	(0.811)	(0.033)	(7.671)
$25,000 - $49,999	-0.0076	-1.1924	0.0150	4.4939
	(0.021)	(0.915)	(0.052)	(6.100)
$50,000 or over	-0.0035	-0.5745	0.0150	-2.3694
	(0.021)	(0.772)	(0.052)	(6.406)
		Employment status		
Employed	0.0065	-0.7047	0.0225	3.4311
	(0.019)	(0.671)	(0.047)	(6.421)
Self-employed	-0.0087	-0.5199	0.0116	17.9489*
	(0.016)	(1.106)	(0.043)	(10.359)
Unemployed	0.0199	-0.4399	0.0273	-5.4823
	(0.023)	(0.854)	(0.029)	(12.523)
Retired	0.0097	-0.6305	-0.0327	10.9114
	(0.024)	(0.899)	(0.034)	(10.358)

*Notes: Standard errors in round brackets are clustered at the state level. Significant levels: p-value *** $\leq$ 0.01, ** $\leq$ 0.05, * $\leq$ 0.1. Each specification includes state and year dummies.*

5.3 Robustness

This subsection presents a number of robustness checks to ascertain whether results are stable across specifications. We take into account various state-time trends, following Liu et al. (2010) and Wehby & Courtemanche (2012), to capture time-varying state unobservable characteristics which may potentially affect our estimates. We also run our baseline models on a subsample of ever-smokers to be certain that our results are not driven by non-smokers' habits.

Table 7 lists estimates for ever-smokers only. These results are very similar to those of Table 2, in that, for each outcome, the effect of a smoking ban is highly significant and with the expected sign. The estimated parameters are not statistically different from baseline estimates for number of drinks and physical activity, but the estimated effect of smoking on the percentage of drinkers is found to be lower in Table 7 than in Table 2. This indicates that, in the baseline model, part of the effect can capture never-smokers' habits.

Tables 8-10 provide a second robustness check to control for time-varying state unobservable characteristics which may potentially affect our estimates. Table 8 shows four specifications (structural forms) in which the outcome of interest is drinking: column 1 lists baseline estimates, controlling for state and year dummies; column 2 adds state dummies and a quadratic trend; the estimates in column 3, compared with those of column 1, also account for state-year interaction terms; column 4, compared with column 2, also controls for state-quadratic trend interactions. Looking at the estimated coefficients, we see that the structural parameters are positive and highly significant, and that point estimates vary from 0.2641 (SE 0.031) in column 2 to 0.2704 (SE 0.031) in column 3, but are not statistically different.

Like Table 8, Table 9 shows the estimated parameters when the number of drinks is the outcome. In this case, estimates are again very stable across specifications, indicating that unobservable time-varying characteristics, captured differently by the four specifications, do not drive our results. Each column shows that coefficients are positive and statistically significant.

With physical activity as outcome, as shown in Table 10, the parameters are negative and highly significant all robustness checks performed. Point estimates are very stable, ranging from -0.295 (SE 0.028) in column 3, when we control for state and year dummies, to -0.262 (SE 0.030) in column 2.

The robustness analysis presented so far addresses the issue of capturing state, time-varying unobservable characteristics (and interactions between them) which may affect our baseline estimates. Tables 7-10 show that, even with those controls, no noticeable differences in estimate magnitude are found. We conclude that our key findings related to smoking ban effects are robust and not driven by unobserved time and/or state heterogeneity.

To test the robustness of the estimated effects of cigarette price on state-specific time trends, we cannot use the same specifications adopted for smoking bans, because in the former case we exploit state and time heterogeneity to identify the role of price. Introducing state-year interactions would imply perfect collinearity with price. In order to overcome this problem we follow Courtemanche (2009) and include state-specific time linear trends and a quadratic term common for all states. This specification is preferable to that in which state-specific time linear trends and year dummies are included, because the variance inflation factor (VIF) associated with the latter is too high to guarantee credible estimates. Instead, the use of a quadratic trend to control for temporal variations in alcohol habits and physical exercise reduced the VIF significantly. Also in the case of cigarette price, we performed a robustness check on the ever-smoker subsample to test whether the presence of non-smokers changed our baseline results.

Tables 11-12 show the effect of cigarette price in the case of ever-smokers and time-varying state unobservable characteristics. Table 11 shows that, although we only focus on ever-smokers, the results remain the same and, here too, no statistically significant effects for any of our outcomes of interest are found, as in Table 4. Instead, when we account for state-specific linear trends, we find evidence of a positive and statistically significant effect of cigarette price on physical exercise (Table 12).

Table 6: Effect of smoking on drinking (various measures) and physical activity. Ever-smokers sample.

	% of smokers	% of drinkers		No. of drinks per month		Physical activity per month	
	Smoking (reduced form)	Drinking (reduced form)	Drinking (structural form)	Drinking (reduced form)	Drinking (structural form)	Physical activity (reduced form)	Physical activity (structural form)
Smoking ban	-0.0817***	-0.0098***		-2.9223***		0.0187***	
	(0.004)	(0.003)		(0.252)		(0.003)	
Percentage of smokers			0.1200***		35.8784***		-0.2328***
			(0.038)		(3.495)		(0.040)
Constant	0.9846***	0.6221***	0.4808***	33.7927***	2.0293	0.5479***	0.8130***
	(0.015)	(0.018)	(0.036)	(1.682)	(3.130)	(0.024)	(0.036)
Observations	117,881	104,922	104,922	103,628	103,628	103,628	103,628
Angrist-Pischke test of excluded instruments			1044.64		2367.39		829.24

*Notes: Standard errors in round brackets are clustered at the state level. Significant levels: p-value *** $\leq$ 0.01, ** $\leq$ 0.05, * $\leq$ 0.1. Each specification includes state and year dummies.*

Table 7: Baseline model robustness to inclusion of various types of state and year controls: % of drinkers

	Model1	Model2	Model3	Model4
Percentage of smokers	0.2664***	0.2641***	0.2704***	0.2689***
	(0.031)	(0.031)	(0.031)	(0.031)
Constant	0.3414***	0.3629***	0.3414***	0.3629***
	(0.022)	(0.086)	(0.022)	(0.086)
Observations	232,696	232,696	232,696	232,696
Angrist-Pischke test of excluded instruments	1630.07	1070.97	1320.78	1212.89
State and year dummies	✓	-	✓	-
State dummies and quadratic trend	-	✓	-	✓
State-year interactions	-	-	✓	-
State-quadratic trend interactions	-	-	-	✓

*Notes: Standard errors in round brackets are clustered at the state level. Significant levels: p-value *** $\leq$ 0.01, ** $\leq$ 0.05, * $\leq$ 0.1.*

Table 8: Baseline model robustness to inclusion of various types of state and year controls: number of drinks per month

	Model1	Model2	Model3	Model4
Percentage of smokers	36.4986***	36.4193***	36.6001***	36.5389***
	(2.116)	(2.112)	(2.120)	(2.119)
Constant	1.6519*	-0.0697	1.6519*	-0.0697
	(0.869)	(1.385)	(0.869)	(1.385)
Observations	254,240	254,240	254,240	254,240
Angrist-Pischke test of excluded instruments	140.05	154.14	161.78	159.75
State and year dummies	✓	-	✓	-
State dummies and quadratic trend	-	✓	-	✓
State-year interactions	-	-	✓	-
State-quadratic trend interactions	-	-	-	✓

*Notes: Standard errors in round brackets are clustered at the state level. Significant levels: p-value *** $\leq$ 0.01, ** $\leq$ 0.05, * $\leq$ 0.1.*

Table 9: Baseline model robustness to inclusion of various types of state and year controls: any physical activity per month

	Model1	Model2	Model3	Model4
Percentage of smokers	-0.2889***	-0.2620***	-0.2952***	-0.2871***
	(0.029)	(0.030)	(0.028)	(0.029)
Constant	0.9376***	-0.1605***	0.9376***	-0.1605***
	(0.015)	(0.017)	(0.015)	(0.017)
Observations	225,009	225,009	225,009	225,009
Angrist-Pischke test of excluded instruments	1935.55	1288.92	1134.81	1092.65
State and year dummies	✓	-	✓	-
State dummies and quadratic trend	-	✓	-	✓
State-year interactions	-	-	✓	-
State-quadratic trend interactions	-	-	-	✓

*Notes: Standard errors in round brackets are clustered at the state level. Significant levels: p-value *** $\leq$ 0.01, ** $\leq$ 0.05, * $\leq$ 0.1.*

Table 10: Effect of cigarette prices on drinking (various measures) and physical activity (various measures). Ever-smoker sample.

	Effect of prices on health behaviors			
	% of drinkers	No. of drinks per month	Physical activity per month	Mins. of physical exercise per day
Retail price	0.0077	-0.7240	0.0086	4.9288
	(0.017)	(0.863)	(0.041)	(6.178)
Constant	0.6972***	41.3171***	0.6285***	64.9001***
	(0.015)	(1.183)	(0.045)	(5.982)
Observations	916,913	899,176	916,913	140,768
R-squared	0.12	0.06	0.29	0.03
Adj. R-squared	0.12	0.06	0.29	0.03

*Notes: Standard errors in round brackets are clustered at the state level. Significant levels: p-value *** $\leq$ 0.01, ** $\leq$ 0.05, * $\leq$ 0.1. Each specification includes state and year dummies.*

Table 11: Effect of cigarette prices on drinking (various measures) and physical activity (various measures). Robustness to inclusion of linear state trends with quadratic time trend

	Effect of prices on health behaviors			
	% of drinkers	No. of drinks per month	Physical activity per month	Mins. of physical exercise per day
Retail price	0.0098	-0.8533	0.5549***	0.1362
	(0.019)	(0.606)	(0.116)	(5.776)
Constant	0.5944***	25.9904***	0.3540***	55.1922***
	(0.017)	(1.028)	(0.114)	(5.137)
Observations	1,879,026	1,847,390	1,879,026	286,013
R-squared	0.13	0.05	0.18	0.03
Adj. R-squared	0.13	0.05	0.18	0.03

*Notes: Standard errors in round brackets are clustered at the state level. Significant levels: p-value *** $\leq$ 0.01, ** $\leq$ 0.05, * $\leq$ 0.1. Each specification includes linear state trends and quadratic term common to all states.*

6 Conclusions

This paper evaluates the possible side-effects of smoking bans on unexplored health outcomes, i.e., drinking habits and physical activity. Although anti-smoking legislation was originally introduced to protect non-smokers from passive smoking, some unintended consequences emerged, some of them positive (reductions in smoking prevalence) and others negative (increased BMI) (Baum 2009, Courtemanche 2009, Liu et al. 2010, Wehby & Courtemanche 2012, Pieroni & Salmasi 2012). We find that, apart from smoking prevalence reductions, there were other positive effects in terms of lifestyle: we estimate that smoking bans gave rise to healthier drinking habits, suggesting complementarity between drinking and smoking, and increases in physical exercise, perhaps motivated by renewed interest in a healthier lifestyle. The positive externalities highlighted with drinking habits are especially important, because a previous study on the effects of smoking bans in bars, restaurants and other public places found an increase in alcohol consumption and increased numbers of car accidents involving alcohol (Adams & Cotti 2008). Instead, workplace smoking bans, which were found to decrease alcohol consumption, may also have prevented its harmful consequences in terms of both alcohol-related diseases and car accidents involving alcohol.

Our results show that the direct effect of smoking bans on the percentage of smokers is statistically significant and negative. In particular, the introduction of anti-smoking legislation reduced smoking participation by about 33%, similar to the results of Liu et al. (2010). In addition, our baseline model results reveal that smoking bans caused a decrease in the percentage of drinkers by 2 percentage points and a reduction in the number of drinks consumed (about 3 drinks per month). Anti-smoking legislation also induced individuals to take physical exercise more often: the ban gave rise to an increase in the percentage of people taking physical exercise by 2 percentage points. We also estimate that a 1% increase in the prevalence of smokers leads to a statistically significant increase in the percentage of drinkers by 8.76 percentage points and a higher number of drinks consumed per month (12 drinks). Regarding physical activity, our results indicate that a 1% increase in smokers' prevalence leads to a decrease of 9.49 points in the percentage of individuals taking physical exercise.

To understand whether these results are policy-specific, we proposed the same analysis using cigarette price (and excise tax). Both interventions, bans and prices, did change the smoking incentives, but acted through different channels: price and excise tax are monetary incentives, irrespective of where cigarettes are smoked, smoking bans exploit other channels and, the stronger their effectiveness, the higher the number of hours individuals are exposed to the restriction, e.g. public places versus workplaces (Evans & Montgomery 1999).

We find that cigarette price had no significant effect on drinking behavior, number of drinks, exercising or minutes of physical activity, except for selected population groups according to number of drinks consumed and intensity of physical activity, i.e. poorly educated and low-income individuals. This result is in line with the monetary incentive argument: cigarette price is likely to have unintended beneficial consequences in terms of healthier lifestyles for the more disadvantaged sectors of the population. Conversely, smoking bans show a more generalized effect: stratified estimates do not show significant differences among population groups and have beneficial effects in all outcomes analysed.

We also provide a robustness check, which shows that results are not generally driven by the non-smoker group, differences in terms of magnitude are found only for drinking, but sign and significance level do not change when ever-smokers are taken into account. More importantly, we also show that time-varying state unobservable characteristics, which may potentially affect our estimates, do not play any role, since estimates are robust to the inclusion of different state and time controls.

References

Adams, S. & Cotti, C. (2008), ‘Drunk driving after the passage of smoking bans in bars’, *Journal of Public Economics* **92**(5-6), 1288–1305.

Adda, J. & Cornaglia, F. (2010), ‘The Effect of Bans and Taxes on Passive Smoking’, *American Economic Journal: Applied Economics* **2**(1), 1–32.

Anger, S., Kvasnicka, M. & Siedler, T. (2011), ‘One last puff? public smoking bans and smoking behavior’, *Journal of Health Economics* **30**(3), 591–601.

Angrist, J. D. (1995), ‘The economic returns to schooling in the west bank and gaza strip’, *American Economic Review* **85**(5), 1065–87.

Baltagi, B. & Goel, R. (1987), ‘Quasi-experimental price elasticities of cigarette demand and the bootlegging effect.’, *American Journal of Agricultural Economics* **69**(4), 750–754.

Baum, C. L. (2009), ‘The effects of cigarette costs on bmi and obesity’, *Health Economics* **18**(1), 3–19.

Becker, G. S., Grossman, M. & Murphy, K. M. (1991), ‘Rational Addiction and the Effect of Price on Consumption’, *American Economic Review* **81**(2), 237–41.

Brady, K. T. & Sonne, S. C. (1999), ‘The role of stress in alcohol use, alcoholism treatment, and relapse’, *Alcohol Research and Health* **23**(4), 263–271.

Businelle, M. S., Lam, C. Y., Kendzor, D. E., Cofta-Woerpel, L., McClure, J. B., Cinciripini, P. M. & Wetter, D. W. (2013), ‘Alcohol consumption and urges to smoke among women during a smoking cessation attempt’, *Experimental and Clinical Psychopharmacology* **21**(1), 1–18.

Chaloupka, F. J. & Grossman, M. (1996), Price, Tobacco Control Policies and Youth Smoking, NBER Working Papers 5740, National Bureau of Economic Research, Inc.

Chaloupka, F. J., Grossman, M. & Tauras, J. A. (1997), ‘Public Policy and Youth Smokeless Tobacco Use’, *Southern Economic Journal* **64**(2), 503–516.

Chaloupka, F. J. & Warner, K. E. (2000), The economics of smoking, *in* A. J. Culyer & J. P. Newhouse, eds, 'Handbook of Health Economics', Vol. 1 of *Handbook of Health Economics*, Elsevier, chapter 29, pp. 1539–1627.

Chaloupka, F. & Saffer, H. (1992), 'Clean indoor air laws and the demand for cigarettes', *Contemporary Economic Policy* **10**, 72–83.

Chapman, S. & Richardson, J. (1990), 'Tobacco excise and declining consumption: The case of Papua New Guinea.', *American Journal of Public Health* **80**(5), 537–540.

Chou, S.-Y., Grossman, M. & Saffer, H. (2004), 'An economic analysis of adult obesity: results from the behavioral risk factor surveillance system', *Journal of Health Economics* **23**(3), 565–587.

Courtemanche, C. (2009), 'Rising cigarette prices and rising obesity: Coincidence or unintended consequence?', *Journal of Health Economics* **28**(4), 781–798.

Crost, B. & Guerrero, S. (2012), 'The effect of alcohol availability on marijuana use: Evidence from the minimum legal drinking age', *Journal of Helath Economics* **forthcoming**.

Dee, T. S. (1999), 'The complementarity of teen smoking and drinking', *Journal of Health Economics* **18**(6), 769–793.

Delfino, R. J., Jamner, L. D. & Whalen, C. K. (2001), 'Temporal analysis of the relationship of smoking behavior and urges to mood states in men versus women', *Nicotine and Tobacco Research* **3**(3), 235–248.

Dragone, D., Manaresi, F. & Savorelli, L. (2013), Tobacco Taxes and Smoking Bans Impact Differently on Obesity and Eating Habits, Working Papers wp878, Dipartimento Scienze Economiche, Universita' di Bologna.

Epstein, A., Sher, T., Young, M. & King, A. (2007), 'Tobacco chippers show robust increases in smoking urge after alcohol consumption', *Psychopharmacology* **190**(3), 321–329.

Evans, W. N., Farrelly, M. C. & Montgomery, E. (1999), 'Do workplace smoking bans reduce smoking?', *American Economic Review* **89**(4), 728–747.

Evans, W.N., F. M. & Montgomery, E. (1999), 'Do workplace smoking bans reduce smoking?', *American Economic Review* **89**(4), 728–747.

Federico, B., Mackenbach, J. P., Eikemo, T. A. & Kunst, A. E. (2012), 'Impact of the 2005 smoke-free policy in italy on prevalence, cessation and intensity of smoking in the overall population and by educational group', *Addiction* **107**(9), 1677–1686.

Fichtenberg, C. & Glantz, S. (2004), 'Effect of smoke-free workplaces on smoking behavior: Systematic review', *British Medical Journal* (325), 188–194.

Frone, M. R. (2008), 'Are work stressors related to employee substance use? the importance of temporal context assessments of alcohol and illicit drug use', *Journal of Applied Psychology* **93**(1), 199–206.

Gallus, S., Pacifici, R. & Colombo, P. e. a. (2006), 'Prevalence of smoking and attitude towards smoking regulation in italy, 2004', *Eur. J. Cancer Prev.* **15**, 77–81.

Grossman, M., Coate, D., Lewit, E. & Shakotko, R. (1983), Economic and Other Factors in Youth Smoking., Technical report, Washington: National Science Foundation.

Gruber, J. & Frakes, M. (2006), 'Does falling smoking lead to rising obesity?', *Journal of Health Economics* **25**(2), 183–197.

Imbens, G. W. & Angrist, J. D. (1994), 'Identification and estimation of local average treatment effects', *Econometrica* **62**(2), 467–75.

Jones, A., Laporte, A., Rice, N. & Zucchelli, E. (2011), A model of the impact of smoking bans on smoking with evidence from bans in england and scotland, Health, Econometrics and Data Group (HEDG) Working Papers 11/05, HEDG, c/o Department of Economics, University of York.

Kennedy, R. D., Behm, I., Craig, L., Thompson, M. E., Fong, G. T., Guignard, R. & Beck, F. (2012), 'Smoking cessation interventions from health care providers before and after the national smoke-free law in france', *European Journal of Public Health* **22**(1), 23–28.

King, A. & Epstein, A. M. (2005), 'Alcohol dose-dependent increases in smoking urge in light smokers', *Alcoholism Clinical and Experimental Research* **29**(4), 547–552.

Lewit, E. M. & Coate, D. (1982), ‘The potential for using excise taxes to reduce smoking’, *Journal of Health Economics* **1**(2), 121–145.

Lewit, E. M., Coate, D. & Grossman, M. (1981), ‘The Effects of Government Regulation on Teenage Smoking’, *Journal of Law and Economics* **24**(3), 545–69.

Liu, F., Zhang, N., Cheng, K.-W. & Wang, H. (2010), ‘Reduced smoking and rising obesity: Does smoking ban in the workplace matter?’, *Economics Letters* **108**(3), 249–252.

Mao, Z. (1996), Demand for Cigarettes and Price Policy: A Time-Series Analysis (in Chinese)., Technical report.

Nagelhout, G. E., de Vries, H., Boudreau, C., Allwright, S., McNeill, A., van den Putte, B., Fong, G. T. & Willemsen, M. C. (2012), ‘Comparative impact of smoke-free legislation on smoking cessation in three european countries’, *European Journal of Public Health* **22**(1), 4–9.

Orzechowski, W. & Walker, R. (2006), The Tax Burden on Tobacco, Historical Compilation, vol. 41., Technical report, Virginia, Arlington.

Peterson, D., Zeger, S., Remington, P. & Anderson, H. (1992), ‘The effect of state cigarette tax increases on cigarette sales 1955-1988.’, *American Journal of Public Health* **82**(1), 94–96.

Piasecki, T. M., McCarthy, D. E., Fiore, M. C. & Baker, T. B. (2008), ‘Alcohol consumption, smoking urge, and the reinforcing effects of cigarettes: An ecological study’, *Psychology of Addictive Behaviors* **22**(2), 230–239.

Picone, G. & Sloan, F. (2003), Smoking Cessation and Lifestyle Changes, *in* ‘Frontiers in Health Policy Research, Volume 6’, NBER Chapters, National Bureau of Economic Research, Inc, pp. 115–142.

Pieroni, L., Chiavarini, M., Minelli, L. & Salmasi, L. (2013), ‘The role of anti-smoking legislation on cigarette and alcohol consumption habits in italy’, *Health Policy* **111**(2), 116–126.

Pieroni, L. & Salmasi, L. (2012), Does cigarette smoking affect body weight? causal estimates from the clean indoor air law discontinuity, MPRA Paper 38338, University Library of Munich, Germany.

Rohsenow, D. J., Monti, P. M., Colby, S. M., Gulliver, S. B., Sirota, A. D., Niaura, R. S. & Abrams, D. B. (1997), 'Effects of alcohol cues on smoking urges and topography among alcoholic men', *Alcoholism Clinical and Experimental Research* **21**(1), 101–107.

Sayette, M. A. (1999), 'Does drinking reduce stress?', *Alcohol Research and Health* **23**, 250–255.

Sweet, C. (2000), *Overcoming Addiction: Positive Steps for Breaking Free of Addiction and Building Self-Esteem*, Piatkus Books, London, England.

US Department of Health and Human Services (1972), 'The health consequences of smoking: A report of the surgeon general', *DHHS Publication CDC* (72-7516).

Van Walbeek, C. (2001), *The Economics of Tobacco Control in South Africa*, Discussion paper series, AFReC.

Wasserman, J., Manning, W. G., Newhouse, J. P. & Winkler, J. D. (1991), 'The effects of excise taxes and regulations on cigarette smoking', *Journal of Health Economics* **10**(1), 43–64.

Wehby, G. L. & Courtemanche, C. J. (2012), 'The heterogeneity of the cigarette price effect on body mass index', *Journal of Health Economics* **31**(5), 719–729.

Wildman, J. & Hollingsworth, B. (2012), 'The impact of the public smoking ban on obesity in australia', *Presented at the 9th European Conference on Health Economics, Zürich* .

Xu, X., Hu, T. & Keeler, T. (1998), Optimal Cigarette Taxation: Theory and Estimation . , Technical report.

Yörük, B. K. & Yörük, C. E. (2011), 'The impact of minimum legal drinking age laws on alcohol consumption, smoking, and marijuana use: Evidence from a regression discontinuity design using exact date of birth', *Journal of Health Economics* **30**(4), 740–752.

APPENDIX A

Table A.1: Effect of cigarette taxes on drinking (various measures) and physical activity (various measures).

	Effect of taxes on health behaviors			
Taxes	0.0001	-0.0058	0.0002	0.0540
	(0.000)	(0.004)	(0.000)	(0.044)
Constant	0.6027***	29.1020***	0.6372***	68.5119***
	(0.013)	(0.892)	(0.023)	(3.561)
Observations	1,879,026	1,847,390	1,879,026	286,013
R-squared	0.13	0.05	0.32	0.03
Adj. R-squared	0.13	0.05	0.32	0.03

*Notes: Standard errors in round brackets are clustered at the state level. Significant levels: p-value *** ≤ 0.01, ** ≤ 0.05, * ≤ 0.1. Each specification includes state and year dummies.*

Table A.2: Effect of cigarette taxes on drinking (various measures) and physical activity (various measures), by socio-economic status.

	Effect of taxes on health behaviors			
	% of drinkers	No. of drinks per month	Physical activity per month	Mins. of physical exercise per day
		Gender		
Men	0.0001	-0.0130**	0.0001	0.0528
	(0.000)	(0.006)	(0.000)	(0.056)
Women	0.0001	0.0006	0.0002	0.0579
	(0.000)	(0.002)	(0.000)	(0.038)
		Age		
18-25	0.0002	-0.0003	0.0000	-0.0144
	(0.000)	(0.006)	(0.000)	(0.060)
25-45	0.0000	-0.0083	0.0002	0.0791
	(0.000)	(0.006)	(0.000)	(0.057)
45-65	-0.0000	-0.0102**	0.0003	0.0449
	(0.000)	(0.005)	(0.000)	(0.062)
65 +	-0.0001	-0.0113*	0.0002	0.1365
	(0.000)	(0.006)	(0.000)	(0.082)
		Race		
White	0.0001	-0.0051	0.0002	0.0561
	(0.000)	(0.004)	(0.000)	(0.054)
Black	0.0002	-0.0022	0.0004	0.0533
	(0.000)	(0.005)	(0.000)	(0.085)
Hispanic	-0.0000	-0.0059	-0.0003	0.1123
	(0.000)	(0.009)	(0.000)	(0.080)
		Education		
Less than high school	-0.0002	-0.0192***	-0.0000	0.2052**
	(0.000)	(0.007)	(0.000)	(0.100)
High school	0.0000	-0.0048	0.0003	0.0048
	(0.000)	(0.005)	(0.000)	(0.123)
Some college training - College diploma	0.0001	-0.0024	0.0003	0.0577
	(0.000)	(0.004)	(0.000)	(0.049)
		Income		
$0 - $24,999	0.0000	-0.0096*	0.0001	0.1016*
	(0.000)	(0.005)	(0.000)	(0.058)
$25,000 - $49,999	-0.0001	-0.0110**	0.0001	0.0372
	(0.000)	(0.005)	(0.000)	(0.048)
$50,000 or over	0.0000	-0.0110**	0.0002	0.0046
	(0.000)	(0.005)	(0.000)	(0.046)
		Employment status		
Employed	0.0001	-0.0060	0.0003	0.0643
	(0.000)	(0.004)	(0.000)	(0.049)
Self-employed	-0.0002	-0.0117	0.0002	0.1702**
	(0.000)	(0.008)	(0.000)	(0.068)
Unemployed	0.0001	-0.0051	0.0002	-0.0385
	(0.000)	(0.006)	(0.000)	(0.087)
Retired	0.0001	-0.0049	-0.0000	-0.0000
	(0.000)	(0.005)	(0.000)	(0.108)

*Notes: Standard errors in round brackets are clustered at the state level. Significant levels: p-value *** $\leq$ 0.01, ** $\leq$ 0.05, * $\leq$ 0.1. Each specification includes state and year dummies.*