Does cigarette smoking affect body weight? causal estimates from the clean indoor air law discontinuity

Luca Pieroni and Luca Salmasi

23. April 2012

Does cigarette smoking affect body weight? Causal estimates from the Clean Indoor Air Law discontinuity

Pieroni L.*, Salmasi L.**

*University of Perugia (Italy) and University of the West of England (UK)

**University of Verona (Italy)

Corresponding author: Pieroni L., Department of Economics, Finance and Statistics,

Via Pascoli 20, 06123 Perugia, Italy. E-mail: lpieroni@unipg.it

Abstract

This paper examines the causal effects of smoking behavior on body weight in Italy. In 2005, the Italian government introduced a smoking ban in all indoor public places. We use a regression discontinuity design, which exploits this exogenous variation across cohorts to achieve identification in our model. Our estimates indicate that the smoking ban reduced cigarette consumption and the smoking participation rate. Most interestingly, we estimate a significative, although not very large, effect of nicotine reduction on weight increases. Heterogeneous effects are also estimated, with smaller impact on men and employees and, conditionally on BMI distribution, overweight and obese people.

Keywords: Smoking ban, overweight and obesity, Local average treatment effect
JEL classification : I10, I12, I18

1 Introduction

Cigarette consumption remains a concern for the worldwide public health agenda, although the percentage of smokers has been continuously falling in the few last decades in both the US and Europe. Until now, much of the research has been addressed to the determinants of smoking and how quitting smoking can be facilitated. Among the most important socio-economic determinants, a relatively large body of studies considers education level. This variable has been found to affect smoking behavior significantly: better educated individuals decrease their cigarette consumption because they are more aware of the health risks connected with consumption of unhealthy goods (Garcia & Labeaga 1996, Jones & Yen 2000, Yen 2005). In addition, the influence of friends' and neighbors' choices on smoking habits appear to be important (Cutler & Glaeser 2009), although intra-household consumption externalities have been estimated to affect individuals' smoking behaviors consistently (Aristei & Pieroni 2010). Another strand of the literature focuses on the negative consequences to health of exposure to smoke by non-smokers (passive smoking), with known effects on the probability of increasing cancer and cardiovascular diseases. These detrimental effects favored the purpose of Clean Indoor Air Laws, and their implementation has demonstrated to reduce both number of smokers and cigarette consumption significantly (Eriksen & Chaloupka 2007).

There are at least two reasons for thinking that the reduction in cigarette consumption is important for economic and health-related outcomes. First, it is generally believed that smoking bans have a negative economic impact on pubs, due to a drop in the number of customers. This result may be reinforced by the fact that going to pubs is due to interpersonal complementarities in smoking consumption (e.g., peer effects) (Cutler & Glaeser 2009). Second, although it has been found that body weight trends are inversely correlated with cigarette consumption, causal estimates indicates that these correlations may be misleading as regards the significance and level of their effects, especially when focused on people at health risk, like those who are overweight and obese (Baum 2009).

In this paper, we focus on the direct effects of the Clean Indoor Air Law, implemented in Italy as from 10 January 2005 on smoking and on its indirect effects on body weight. Assuming that the application of this policy significantly affected smoking, we test whether it also had health-related consequences in terms of body weight. As we discuss in depth in Section 2, there are several reasons for expecting that less smoking significantly affects body weight. The main reasons are the direct effects on individuals' metabolic rates and life-style changes concerning food consumption.

Section 3 presents the empirical implications of the 2005 Italian smoking ban on body weight, under the hypothesis, generally not rejected, that implementation of the law increased the individual cost of smoking, with the probable negative effect on cigarette consumption and the positive one of quitting smoking. Our strategy exploits the discontinuity introduced by the law on smoking variables, to measure the reaction in terms of BMI, intended as a health risk outcome, unobserved confounders being netted out; these estimates are then used to calculate the variation in terms of body weight. In addition, we overcome the common problem in public health literature, which examines the effect of smoking on weight outcomes by means of reduced-form models, and we estimate a structural model based on more appealing theoretical foundations (Heckman et al. 2008). For model identification, we take advantage of the fact that individuals of the same age, but born in adjacent cohorts, experiment different types of smoking restrictions. We argue that, although all other determinants of smoking vary rapidly in time, they should not have changed discontinuously in 2005. This allows us to attribute any drop in smoking habits around that year to the introduction of the ban. The descriptive sub–section motivates our paper empirically. We know that the long-run trend of Italian smokers declined from 60% in the early 1960s to 30% in 2004, but remained surprisingly stable (around 23%) for women. Similar trends were observed for cigarette consumption (Colombo et al. 2002). Conversely, body weight in Italy, expressed in terms of BMI, has increased consistently, although only in the last decade (Pieroni et al. 2011). Using the ''Everyday Life Aspects" (ELA), a representative sample of microdata for Italy from 2001 to 2007, we can focus appropriately on this evidence and examine the magnitude of changes in smoking habits and BMI. More interestingly, in terms of causal effects of smoking on body weight, we show that the introduction of the Clean Indoor Air Law implied a significant discontinuity on these variables.

In section 4, we specifically examine empirical predictions. Since we base our study on the significant effect of the smoking ban on quitting or reducing smoking, we first examine whether the estimated coefficients of reduced forms explain the variability around the discontinuity introduced by the law. We also estimate whether the ban shows significant correlations with BMI. Then, using a structural model, we test whether individuals' weight gain can be associated with nicotine consumption reduction. To account for the length of the observed period, which is responsible for the large variability of outcomes generally found for this relationship, we estimate the causal effect by a regression discontinuity (RD) design, using observations collected in the years immediately before and after the smoking ban came into force (2003 and 2005) and over a more extended time period, considering the whole sample (2001-2007) within an IV setting.

Our empirical results indicate that quitters account for almost the entire variability in weight changes, irrespective of whether we use RD or IV whole sample. In addition, our RD estimates measure the BMI response to an exogenous variation in the opportunity cost of smoking at a given point in time (e.g. 2005). Standardized for one year, they reveal an impact which is greater than that obtained from IV estimates in whole sample that, instead, account for a medium-period effect of three years. Comparing our results for employed individuals, male and female groups and obese individuals, we also examine the prediction that heterogeneous groups can generate different impacts on weight changes. We estimate that, post-ban smoking changes for employed individuals would yield a lower response on BMI, but a large impact was estimated for the female group, irrespective of the sample used. Lastly, we estimate our model at the 77^{th} and 81^{th} percentiles of the BMI distribution, corresponding respectively to the average values of i) overweight; and ii) overweight and obese groups. The results indicated an adverse impact on weight, although BMI elasticity to cigarette consumption were found to be lower in these health risk groups than those estimated for the entire sample.

In Section 5, we carried out robustness checks for previous IV estimates (2001-2007) using the inverse distance weight estimator (IDW), to test whether the estimates are affected by unobserved heterogeneity. We reject this hypothesis, and show that estimated parameters are close to baseline IV estimates. Also supported by other robustness analyses, the effects of nicotine consumption variations and quitting smoking on body weight are presented according to parameters estimated on the RD sample. We estimate that lower cigarette consumption gives rise to a weight increase of 3.2 kg with respect to smokers. However, much of this effect (2.8 kg) is that due to quitting. Employees' weight is less affected by changes in smoking (2.3 kg) but, in women, among those who stop or reduce smoking, the increase is estimated to be close to 5.5 kg. The adverse and unintended consequences on overweight and obese people are not great and do not exceed 1 kg. Section 6 concludes.

2 Related literature

2.1 Clean indoor air laws: direct effects on smoking and business

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 a number of public places. This law certified that ''nonsmokers had as much a right to clean air and wholesome air as smokers had to their so-called right to smoke". The motivations for state intervention, thereafter flexibly applied during the 1970s to other US states, were followed by the Surgeon General's Report[1], which emphasized the adverse health effects of passive smoking on public health.

With the exception of Finland[2], European Clean Indoor Air Laws are relatively more recent. This explains why most studies of the economic impact of smoking bans are based on US data, as more detailed European smoke-free interventions adopting comprehensive smoking bans in virtually all public places and private worksites followed from the US experience.

This legislation not only protected non-smokers from the dangers of passive smoking, but also encouraged smokers to quit or reduce their consumption[3]. However, until now, there has been limited evidence about the consequences of non-smokers' exposure to cigarette smoke. Several studies have shown that these laws help prevent young people from starting smoking, reduce the number of cigarettes smoked, and encourage some smokers to quit. One classic health economics paper analyzing the effects of cigarette consumption and the prevalence rate of smoking bans is that of Chaloupka & Saffer (1992). The authors, according with Evans et al. (1999), emphasize that, while prohibiting smoking at the work place is effective in reducing prevalence and consumption, these effects are much smaller than those obtained when restrictions are introduced only in public places, because in the first case the amount of time spent

[1] US Department of Health and Human Services (1972).

[2] The Finnish Tobacco Control Act (TCA) was first implemented in 1976 and progressively extended in more recent years.

[3] Adda & Cornaglia (2010) show that bans affect non-smokers differently, increasing the exposure of poorer individuals with respect to richer individuals.

without being able to smoke is greater.

However, more detailed contributions about the effects of smoking regulation appear in the epidemiological literature. In a survey conducted in Ireland after the 2004 introduction of smoke-free legislation, Anonymous (2005) and Fong et al. (2006) found that, among Irish smokers who quitted after the ban, 80% reported that the law had helped them to quit and 88% that it had helped them to remain non-smokers. Gallus et al. (2006), evaluating the 2005 Italian law for smoke-free public places, estimated that betweeen 2004 and 2006 smoking prevalence decreased by 1.9% and that the daily number of cigarettes decreased by 9.5%[4]. These results are in line with those found in other countries, such as the USA, Australia, Canada and Germany (Fichtenberg & Glantz 2004). Note that this literature also emphasized differences by gender. For example, Chaloupka (1992) finds that clean indoor air laws are more effective for male smokers.

Another strand of the literature indicates that smoke-free policies and regulations have been used to evaluate the negative economic impact on the catering and hotel industries, a position largely supported by the tobacco industry (Scollo et al. 2003). Following the reviews of Scollo et al. (2003) and Eriksen & Chaloupka (2007), the position of the tobacco industry was clearly contradicted by almost all the scientific evidence, indicating that there was no negative economic impact of clean indoor air policies on revenues for bars, pubs and restaurants. This evidences is in line with that presented in the 2006 Surgeon General's Report by the US Department of Health and Human Services (2006). Eriksen & Chaloupka (2007) also review studies, finding a positive effect of smoke-free restaurant and *café* laws on economic activity, employment and revenues[5]. In the European context, the issue is still under debate and conflicting evidence on the subject is recorded. Italian data showed higher numbers of people frequenting restaurants and *cafés* after the implementation of the smoking ban, a prediction in line with the US context (Gallus et al. 2006). While, a drop in the number of customers, at least in the short-run, was observed after the introduction of the clean indoor air law in Scotland (Adda et al. 2012).

2.2 Smoking reductions, BMI and obesity

2.2.1 The medical perspective

Why should quitting (or reducing) smoking increase body weight? The medical literature gives two main reasons: (1) a direct change in metabolic rates; (2) a life-style change in food consumption. In this section, we briefly discuss these reasons. We anticipate that these effects have been measured and discussed so far mainly for quitters, in which the addictive effects of nicotine consumption have been found to affect weight generally with extended consequences to other related health outcomes.

Quitting smoking may increase body weight because changes in nicotine assumption produce effects on human metabolism. Thus, the observed weight increase generally recorded after quitting, as already

[4]Gallus et al. (2006) also found that the drop in smoking prevalence and consumption is particurarly significant for younger generations.

[5]See, for example Luk et al. (2011) for the positive findings of the smoke-free law on the restaurant and bar sales in Ottawa, Canada.

discussed in Keys et al. (1966), Karvonen et al. (1959) and Higgins (1967), does not turn out to be very large when empirical analysis also accounts for dietary habits. In particular, Grunberg (1985), Klesges et al. (1989), French & Jeffery (1995) explained that the weight gap between smokers and non-smokers was entirely due to differences in metabolic rates and to the more efficient ability of smokers to burn calories during the day. This result was also confirmed by the regularity with which the heart may beat 10-20 more times per minute after a cigarette has been smoked, whereas, after quitting, the metabolic rate slows down and returns to its average level (for pioneering studies, see Dill et al. (1934), Jacobs et al. (1965) and Glauser et al. (1970)). Thus, reductions in cigarette consumption may lead to gains in terms of smoke-related illnesses, with additional indirect positive effects on body weight[6].

Secondly, quitting smoking is often associated with changes in eating habits and preferences. A common symptom after quitting is an increase in food intake, which affects weight for longer than other symptoms. Increased appetite has traditionally been attributed to the fact that eating is a substitute for smoking; eating or snacking is similar to the action of smoking and can be used as a means of oral gratification Jacobs & Gottenberg (1981). In addition, preferences may also change. The sense of taste and smell return to be close to those of non-smokers, implying a larger propensity to move toward unhealthy food, which usually has higher calorie contents (Drewnowski & Darmon 2005). Conversely, psychiatric studies have shown that quitters tend to be less depressed and exhibit fewer negative effects when they successfully quit than subjects who continue smoking (Cinciripini et al. 2003). Emotional states have therefore been associated with both weight loss and weight gain (Wurtman 1993, Barefoot et al. 1998), and this may partly explain the variability of results and possible unexpected findings.

2.2.2 Smoking habits and BMI: estimates

One strand of economics literature has tested the hypothesis that stopping (or reducing) smoking causes weight gain, generally measured in terms of BMI. As a special focus, these works evaluated this relationship in the obese sub-group. For example, Chou et al. (2004) produced two new important perspectives using: (i) a large dataset for the US, the Behavioral Risk Factor Surveillance System (BRFSS), which includes health and socio-economic variables; (ii) and state-wide policies as a proxy instrument for smoking habits. Their estimates showed a positive relationship between cigarette prices and body weight, indicating that a decrease in smoking is responsible for increased obesity rates. Conversely, Gruber & Frakes (2006) found an adverse relationship between cigarette taxes and BMI, with a non-significant effect on obesity. Lastly, Baum (2009), after carefully controlling for state-specific time trends, suggested that both cigarette taxes and prices had positive effects on BMI and obesity prevalence.

Although these studies are comparable as regards the dataset used and state-wide policy instruments, there is no agreement in terms of the magnitude of the effects, especially in obese individuals. Clearly, the limitation emerging from the analyses is that state cigarette prices (or taxes) contain few within-state variations and are highly collinear with state dummy variables. This implies that their results may not

[6]This prediction matches the findings of Sargent et al. (2004) and Juster et al. (2007).

only have high standard errors for the estimated coefficients, but may also be affected by unobserved confounders. Since smoking is an (individual) endogenous decision, the estimated parameters may turn out to be biased, since unobserved factors may be correlated with other risk behavior also affecting body weight (Viscusi & Hersch 2001, Aristei & Pieroni 2010)[7]. To clarify the importance of this point, we refer to the meta-analysis of Klesges et al. (1989), according to which weight gains range from 0.2 to 8.2 kg that are mainly explicited in the short-term. Klesges et al. (1989) estimate that, six months after quitting, body weight increases on average between 2 and 5 kg. However, Courtemanche (2009) shows that a rise in cigarette prices may also lead to a long-term reduction in body weight, questioning the positive effect of smoking reduction in weight gains.

In order to control for these issues, Liu et al. (2010) employed workplace smoking bans at US state level as an instrument for showing reduction in smoking or participation rate. The idea that we share with this study is using the discontinuity introduced by the policy intervention as a natural instrument. The anti-smoking ban is exogenous since: (i) it is enforced by the state, and (ii) is a universal program. With data from the BRFSS for the years 1998-2006, the above authors found that, when compared with IV estimates, OLS underestimated the impact on BMI of all and obese individuals. The magnitude of OLS estimates indicated that current smokers had between 1.2 (fewer controls) and 1.8 (more controls) lower BMI, than never and former smokers, but these more than doubled when the estimates were carried out with the IV estimator [-3.6 (fewer controls) and -4.2 (more controls)]. Although these results provided evidence that reducing smoking leads to a rise in body weight, they could not estimate the effect for a fixed post–ban period, because in the BRFSS data (both pooled or pseudo-panel) smoking bans were implemented at different periods for each state and thus did not have an homogeneous comparable period. Thus, the interpretation of estimated parameters should be related to a weighted-time post-reform outcome, an issue which limits comparisons of weight effects obtained from randomized evaluation programs in the medical literature (see, for example, Eisenberg & Quinn (2006)).

Our paper contributes to the literature reviewed in three ways. First, we explain weight gains by reductions in nicotine assumption determined either by quitters or smokers who reduce their cigarette consumption, on the basis of the trade-off between the expected benefits and the fixed costs associated with quitting or reducing smoking. The former behavior is usually particularly associated with high costs due to nicotine addiction and withdrawal[8]. Second, we estimate the effects of smoking habit changes on weight in the short term (i.e., after one year) and medium term (after three years), so that our quasi-experiment analysis is consistent with time different responses generally investigated in the medical framework. Third, we add empirical evidence of the causal effect of smoking on body weight. Despite a growing literature, in European countries little is known to what extent individuals' smoking choices affect body weight and even less about causal interpretations of model parameters.

[7]Reverse causality is also plausible, since overweight people choose smoking as a method of weight control (Cawley et al. 2004, Rees & Sabia 2010).

[8]This theory refers to the rational addiction model of Becker & Murphy (1988), in which the development of nicotine dependence can be characterized in terms of tolerance, reinforcement and withdrawal effects.

3 Framework of the analysis

We focus attention here on the need to draw causal estimates of the effect of smoking on body weight. As in Liu et al. (2010), we isolate the effect of smoking from other confounding factors which may also affect BMI by using a structural model. In sub-section 3.2, we motivate the use of the regression-discontinuity design from the evidence of significant differences in BMI and smoking indicators before and after the implementation of the ban.

3.1 A model for the causal relationship between smoking and BMI

Estimating the magnitude of the causal effect of reducing smoking on weight is a non-trivial challenge. In particular, many empirical studies have documented a negative association between cigarette consumption and BMI, although it is not clear whether BMI increases are also unintended consequences of reducing smoking and if so, what portion of this increase may be attributed to them (Nonnemaker et al. 2009). At this stage, we write a simple reduced form equation for a direct estimation of the relation between smoking variables (S_{it}) and body mass index (BMI_{it}) for each individual i at time t. That is:

$$BMI_{it} = \gamma_0 + \gamma_1 S_{it} + \sum_{j=0}^{J} \psi_j X_{jit} + \epsilon_{it}; \tag{1}$$

where X_{jit} is a set of j control variables and ϵ_{it} is an error term.

However, identification of the causal effect requires being able to control for heterogeneity in individuals' smoking and weight choices, so that we are sure that the estimated effect on BMI is not correlated with personal or social factors. If individuals' unobserved characteristics influence BMI changes, as well as smoking behavior, then least square estimates (OLS) of γ_1 will be biased. That is, unobserved variables affecting smoking behaviors may also be correlated with those influencing decisions to change body weight. For example, γ_1 may be estimated to be negative, although smoking variable S has no causal effect on BMI. In this case, OLS estimates of γ_1 would be confounded by the existence of omitted variable bias. One would expect, for instance, that quitters (or individuals who reduce smoking) are more likely to adopt some other behavior such as eating more, which may increase BMI. Thus, we may observe a negative correlation between smoking and BMI, even when we do not have any causal effect between variables.

To estimate causal parameters of the investigated relationship, we need of an IV setting (Hahn et al. 2001). The implementation of clean indoor air laws allows us to identify the relationship between smoking behavior and body weight within a regression discontinuity design[9]. According to the 2005 Italian law, smokers are not permitted to smoke in public and sometimes not even in private places. Therefore, individuals of the same age living in pre- and post-ban periods experience different smoking restrictions, or treatments, and assignment to treatment was only determined by individuals' birth cohort.

[9] Classic references are Trochim (1984, 2001) and Trochim & Campbell (1960).

However, unlike other models in the health literature already described in Section 2, we use a structural model derived from combination of the reduced forms. Identification is achieved by including a dummy variable (SB) in the first-stage equations of smoking behavior and BMI, to record the exogenous change in smoking introduced by the law. We define the smoking ban dummy variable as one for cohorts of individuals interviewed after the introduction of the smoking ban and zero for individuals of the same age but belonging to cohorts interviewed before the introduction of the smoking ban discontinuity. The discontinuity is generated for individuals belonging to each birth cohort after the year in which the ban took effect. The relevant reduced forms for smoking variables and BMI are the following:

$$BMI_{it} = \beta_0 + \beta_1 SB + \sum_{j=0}^{J} \phi_j X_{jit} + u_{it}; \tag{2}$$

and

$$S_{it} = \delta_0 + \delta_1 SB + \sum_{j=0}^{J} \psi_j X_{jit} + v_{it}. \tag{3}$$

We then follow the structural model proposed by Machin et al. (2011)[10] to derive BMI causal estimates. Formally, this is given as:

$$BMI_{it} = \theta_0 + \theta_1 S_{it} + \sum_{j=0}^{J} \sigma_j X_{jit} + \eta_{it}; \tag{4}$$

where IV estimates of the coefficient on the BMI variable in equation (4) is the ratio of the reduced form coefficients in (2) and (3), $\theta_1 = \beta_1/\delta_1$.

This strategy identifies the average causal effect for those individuals (smokers or quitters after the ban), subjected to restrictions in smoking by the virtue of the ban, and allows us to estimate the local average treatment effect (LATE)[11]. Note that, the variation induced by the instrument is local in nature, as it has an impact only for smokers who quit or reduced smoking in the post-ban period.

Thus, the estimated effect according to our empirical approach is obtained by variations in smoking habits and BMI of those subjects who alter their status (treatment), because they react to the ban (instrument). This implies two important consequences in the estimation process. First, IV estimates exceed the OLS ones, at least because the instrument used is based on a policy intervention which only affects the choices of the smoking group. The ban does not affect smokers who continue to smoke or non-smokers. Second, we can calculate the full contribution of nicotine reduction in affecting body weight because, in addition to the quitters, there are individuals who may reduce cigarette consumption. For this reason, we consider two different smoking indicators: number of cigarettes smoked, and participation rates, to examine respectively the effect of changes in nicotine consumption and quitting smoking.

[10]The authors develop a structural model of crime reducing effect of education. A more general discussion of the bridge between structural and program evaluation approaches to evaluating policy is proposed in Keane et al. (2011), Abbring & Heckman (2007), Heckman & Vytlacil (2007)

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

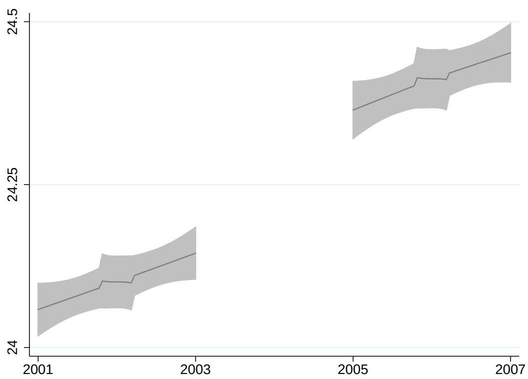
3.2 Data and related empirical issues

The dataset used in this paper is the ELA survey, conducted in Italy by the Italian Statistical Institute (ISTAT). The ELA survey is a representative cross-section sample of the Italian population and provides detailed information on the demographics, social characteristics and health of 20,000 households each year, corresponding to approximately 50,000 individual records yearly.

For the aims of the present study, the importance of this survey lies in the detailed section devoted to analysis of current and past smoking habits of individuals aged 18 and over. In particular, we focus on individual smoking behavior, in terms of both participation rate and cigarette consumption. Contrary to the ISTAT ''Italian Household Budget Survey", ELA provides information on individuals rather than on households, allowing through analysis of socio-demographic and gender effects, without approximating them with the characteristics of the household head.

We used six rounds of this survey, corresponding to the years 2001 to 2007 (excluding 2004, for which data were not available). We selected a sample of individuals aged from 20 to 60 years in the pre-ban period 2001 - 2003, and compare them with individuals of the same age in the post-ban period, 2005 - 2007. Thus, we can compare smoking and BMI patterns for individuals of the same age around the discontinuity generated through the ban, where pre-ban periods observations constitute a proper counterfactual, with the most similar observable and unobservable characteristics, for treated individuals.

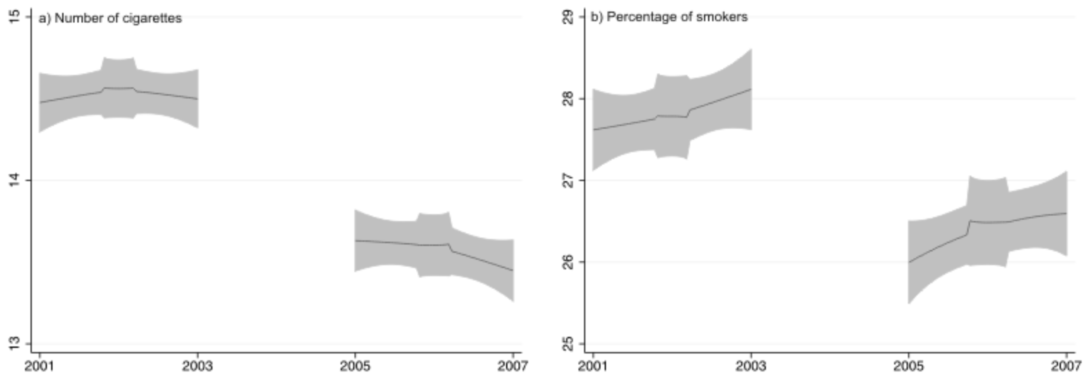
Following Hahn et al. (2001) and Oreopoulos (2006), to guarantee that we correctly estimate the causal impact of nicotine reduction on BMI, one condition is that the average effect of key variables is not null around the discontinuity. We illustrate descriptively the average effect of the smoking ban using the mean of total nicotine consumption (e.g., number of cigarettes) and the percentage of smokers for the years available in our sample. We complement the descriptive analysis of BMI variables around the discontinuity (see plot in Figure 1). We see that, although BMI seems to make a significant jump in the ban year (2005), it then continues along its (positive) long-run growth path.



Notes: BMI values for each year were obtained aggregating individual level data in pre- and post-reform periods. The solid line is estimated by the standard Kernel function.

Figure 1: BMI discontinuity around the clean indoor air law.

Figure 2 (panel a) shows the average number of cigarettes smoked and (panel b) the average percentage of smokers per year. Also in this case, we find a clear deviation from the long-term pattern of these variables in the year of the ban. The mean number of cigarettes smoked felt from 14.5 to almost 13.5, whereas the percentage of smokers decreased by almost 2 percentage points near the discontinuity. These findings indicate that the reform likely played a significant role in reducing smoking, considering both cigarette consumption and percentage of smokers.



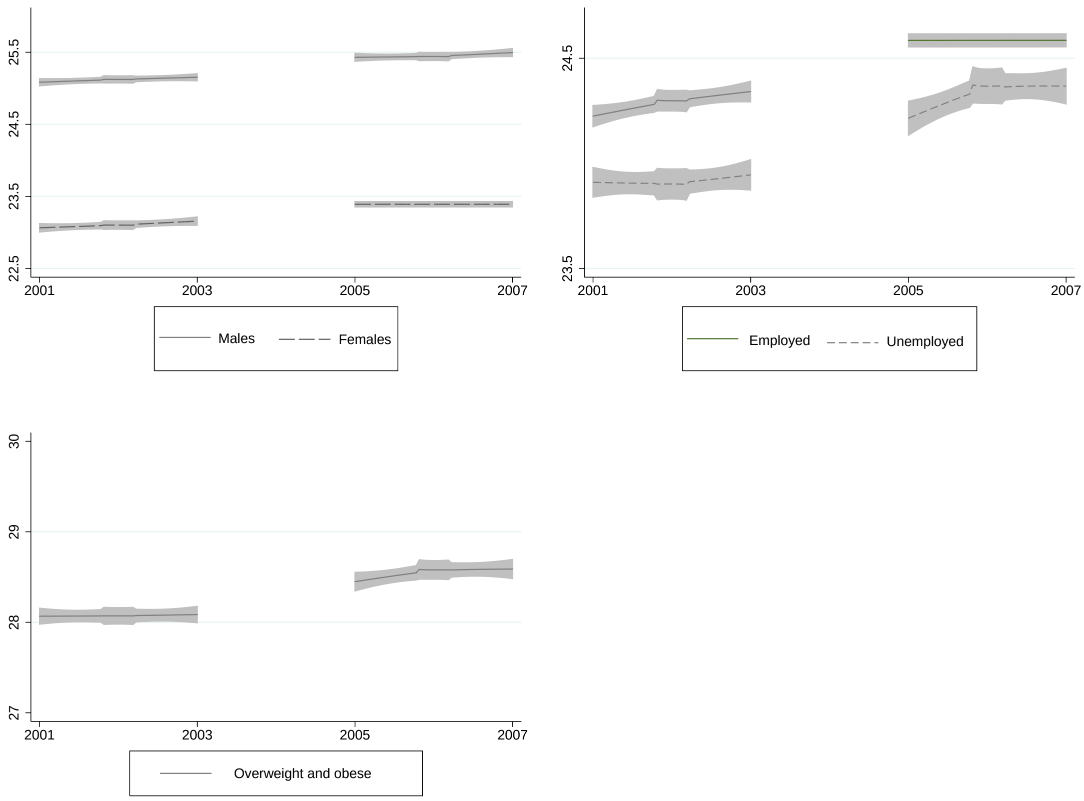
Note: Estimations for number of cigarettes and percentage of smokers are obtained as in Figure 1.

Figure 2: Smoking discontinuities around Italian clean indoor air law (2005). (a) Number of cigarettes; (b) Smoking participation rate

Clearly, there are a number of other issues involved in the analysis between smoking behavior and BMI. First, without the Italian ban, the average BMI for smokers would have undergone the same variation as that for non-smokers. This assumption may be implausible, if treated and control subjects are unbalanced in the covariates which are believed to be associated with heterogeneity in unobservable characteristics. We therefore also include a set of control variables for gender, education, employment status, physical activity and job strenuousness (see Table 1).

In particular, the literature findings discussed in Section 2 indicate that the smoking ban affected differently cigarette consumption through gender and occupation, and that these changes heterogeneously influenced the BMI distribution (Figure 3). Although women (dashed line) have lower BMI than men (solid line), both recorded significant changes in 2005. According to the descriptive statistics of Table 1, the greater response in terms of smoking habits after the ban was associated with men rather than women. In addition, although a larger impact in cigarette consumption affected the employee group rather than the unemployed one, BMI changes in these groups do not appear to be very different. This implies that the effect of smoking on BMI for these sub-groups is not predictable a priori and should be further investigated empirically.

In section 4, we also extend evaluation of the impact of the smoking ban on BMI to these specific sub–groups. We also analyze individuals located at the top of the BMI distribution (e.g., overweight and obese people), who represent a particular risk group in terms of public health policies. We devote our attention to the quantile treatment effect at the mean of overweight and overweight and obese groups, corresponding respectively to the 77^{th} and 81^{st} percentiles of the BMI distribution. Note that, following Imbens & Rubin (1997), consistent estimates of the quantile treatment effect can be obtained under the LATE identifying assumption (and regression discontinuity design) from the marginal distribution of potential outcomes of smokers. In Table 1, the results indicate significant changes in nicotine consumption (and quitters) whereas non-parametric estimates show a very small BMI variation for such sub-groups after the introduction of the smoking ban (Figure 3).



Note: Estimations for BMI patterns of the subsamples are obtained as in Figure 1

Figure 3: BMI discontinuities around the clear indoor air law, by subgroups.

Second, the identification based on the discontinuity introduced by the ban exploits the assumption that individual BMI differences at the same age are only attributable to changes in smoking behavior, whereas all the other weight determinants are stable. This assumption does not exclude the possibility that smokers and non-smoker may have heterogeneous BMI across different birth cohorts, before and after the discontinuity. Figure 4 shows a 5-year cohort reconstruction for the key variables of our model. Each line represents the evolution of a different indicator for individuals belonging to the same cohort, showing that individuals belonging to younger cohorts tend to have higher BMI (and consequently weight) than those belonging to older ones, age being constant. Thus, to control for these inter-generational differences, we include $n-1$ dummy cohorts in our model.

Third, the estimates of the impact of changes in smoking behavior on BMI may be sensitive to how

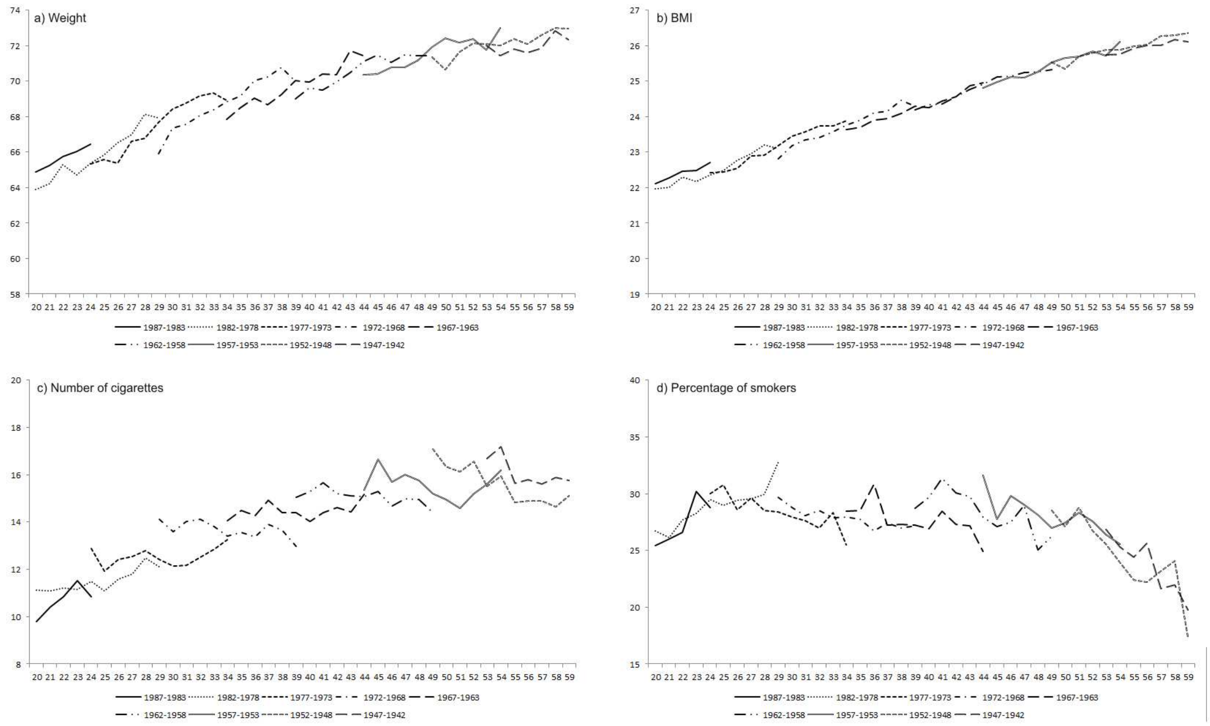
Table 1: Variables definition and descriptive statistics

	Category		Percentage of smokers				Cigarettes consumption (nr.)			
			whole sample		discontinuity		whole sample		discontinuity	
		%	2001-03	2005-07	2003	2005	2001-03	2005-07	2003	2005
Covariates										
Gender	Male	0.49	0.35	0.33	0.35	0.32	16.31	15.16	15.88	15.03
	Female	0.51	0.22	0.21	0.22	0.2	11.95	11.17	11.61	11.07
Occupation	Employed	0.65	0.31	0.29	0.31	0.28	15.09	13.91	14.65	13.83
	Unemployed	0.35	0.23	0.23	0.23	0.21	13.51	12.78	13.12	12.57
Education	Degree or more	0.54	0.25	0.24	0.25	0.24	13.39	12.23	13	12.1
	Secondary or less	0.46	0.31	0.3	0.32	0.29	15.74	14.92	15.3	14.81
Physical activity	No	0.8	0.29	0.28	0.29	0.27	15.11	14.05	14.69	13.91
	Yes	0.2	0.25	0.23	0.25	0.22	12.32	11.35	11.96	11.41
Work at home	Low	0.31	0.31	0.29	0.32	0.3	15.3	14.02	14.85	14.06
strenuousness	Moderate or high	0.69	0.25	0.23	0.25	0.22	13.47	12.57	13.13	12.53
Work strenuousness	Low	0.24	0.25	0.22	0.25	0.22	13.74	12.59	13.28	12.87
	Moderate or high	0.76	0.32	0.3	0.32	0.3	15.26	14.12	14.9	13.94
Marital status	Married	0.6	0.26	0.24	0.26	0.23	15.19	14.13	14.68	14.03
	Single	0.4	0.32	0.31	0.32	0.3	13.91	12.97	13.65	12.82
Subsamples										
Overweight	No	0.7	0.27	0.26	0.28	0.25	13.97	12.99	13.56	12.85
	Yes	0.3	0.3	0.28	0.29	0.27	16.03	14.8	15.65	14.74
Overweight and	No	0.62	0.28	0.26	0.28	0.26	13.58	12.57	13.15	12.43
obese	Yes	0.38	0.29	0.27	0.29	0.26	16.32	15.08	15.97	15.03
All		1	0.28	0.27	0.28	0.26	14.62	13.58	14.21	13.47

Notes: We report percentage of cases and averages variables in pre- and post-reform periods, for the whole sample (2001-2003 and 2005-2007) and for the discontinuity sample (2003-2005) in each variable used to estimate the causal relationship between smoking and body weight.

distant the data are from the discontinuity. In line with the results of the review by Eisenberg & Quinn (2006) this relationship assumes a concave form whether short term responses of smokers are more sensitive in terms of weight gains. Under this hypothesis, our baseline model is estimated with the RD design (2003-2005), in which the structural parameters from this sample (one year post-reform variation) may be greater than those obtained from the whole sample, which considers a three years post-reform (2001-2003 compared to 2005-2007).

In the robustness section, we also provide estimates for the whole period by means of an estimator that weights observations inversely to distance (i.e., IDW, inverse distance weighted) of each year from the smoking ban to eventually investigate the magnitude of unobserved heterogeneity.



Note: A cohort is defined as a group with fixed membership made up of individuals, who can be identified as they show up in the surveys (See, for example, Deaton (1985)). In the figures, each connected line represents the key variable behaviors (body weight, BMI, number of cigarettes and percentage of smokers) of a cohort over the years of observation. This representation permits some preliminary consideration about the presence of age and cohort effects (Kapteyn et al. 2005). The vertical difference between lines measures the cohort-time effect: differences between the key variables observed at the same age, but with different year of birth, highlight the presence of generational (or cohort) effects. On the other hand, differences along the same line measure the age-time effects.

Figure 4: Cohort patterns of: (a) Weight; (b) BMI; (c) Number of cigarettes; (d) Smoking participation rate

4 Results

4.1 IV and RD estimates

In this section, we present the results of our empirical analysis. Table 2 lists the estimated coefficients of the reduced form for equation (1) and the structural framework from equation $(2-4)$, separately for the whole (years 2001-2003 and 2005-2007, columns 1-5) and RD (years 2003 and 2005, columns 6-10) samples. Column (1) shows a positive correlation between the implementation of the clean indoor air law in Italy and body weight increases, with an estimated change of 0.59 unit points of BMI [s.e.=0.024]. As expected, the ban is significantly correlated with reduced nicotine consumption in terms of number of cigarettes smoked [(-0.41; s.e.= 0.062)] and percentage of smokers [(-1.65; s.e.= 0.346)]. Given this exogenous policy shock, our causal estimates indicate the adverse impact of cigarette consumption on BMI [ΔBMI=-1.45; s.e.=0.253]. It is worth noting that the BMI variation induced by the percentage of smokers substantially accounts for all smoking-related variations in BMI. To obtain this result we must compare BMI changes in unitary points. In other words, starting from the estimated coefficient of -0.36 [s.e.=0.08], associated with the share of smokers in the whole sample (i.e. 0.27; see Table 1), in order to obtain the effect of this variable on BMI for the entire population we must multiply this coefficient by the inverse of the share of smokers in the sample (Baker et al. 2008, Havnes & Mogstad 2010). In our example, the impact of participation rate (quitters) on BMI is -1.33 (i.e., $-0.36/.27$) and, according to this estimate, the residual contribution to BMI by smokers that reduce cigarette consumption is quite small and limited.

Another important fact to be noted is that, as Figures 1 and 2 also show, the effect of changes in smoking habits estimated by RD on BMI, is substantially expected to be greater when measured per-period (i.e., one year): the estimated correlation between the smoking ban dummy and BMI, reported in column (6), is significant[12] [(0.36; s.e= 0.04)], and is propedeutic in explaining that much of the causal variation in BMI by quitting smoking happens in the short term, as determined by the structural coefficients reported in columns (8) and (10), respectively. Our estimates indicate that 56% of the total BMI variation in the period (2005–2007) occurs in the first year (i.e., 0.82/1.45). This result derives from the fact that the coefficients estimated from the reduced forms for smoking rise in absolute magnitude. Unsurprisingly, these findings are in line with those of many empirical works in the US which are in accord with the adverse effect of public policies promoting a smoke-free environment and reduced cigarette consumption (e.g., Wasserman et al. (1991), Yurekli & Zhang (2000), Tauras (2005)). In this paper, we also conclude that the immediate reaction to the Italian ban on smoking led to substantial short-term decreases in the smoking participation rate, a phenomenon which weakens over the post-ban period of three years. This result also helps us to clarify the interpretation of the causal effect estimated for our response variable.

The models presented in Table 2 account for differences in observable and unobservable heterogeneity, including a set of covariates listed in Table 1. All covariates are generally significant in our estimates. This allows us to test, according to the economic health literature, the possibility of heterogeneous behavior between subgroups as, for example, employed subjects. We investigate whether the implementation of the smoking ban caused heterogeneous drops in smoking behavior for employees with respect to the entire population. One potential concern with these estimates is that extending the already existing prohibition to smoke in offices also to common areas, our results may underestimate the effect of employed smokers on BMI.

Reduced form estimates, listed in columns (2) and (4) (whole sample) and (7) and (9) (RD sample) of Table 3 indicate that the ban significantly affects smoking habits for employed subjects. Interestingly, the effect for this group is larger than that obtained from baseline estimates, for each smoking variable and irrespective of the sample used. In contrast, the coefficient associated to the BMI variation induced by the ban for employees (equation 2), is close to that obtained from the baseline estimates (columns 1 and 6). Consequently, a limited BMI increase due to reduced smoking is found in the structural equation, in which the unitary reduction in cigarette consumption increases BMI by 0.96 (s.e.= 0.113) in three years and 0.63 (s.e.= 0.129) one year after the ban generated discontinuity.

[12] A similar analysis was recently proposed by **?** to evaluate the effect of minimum legal drinking age laws on alcohol consumption, smoking, and marijuana use

The fact that estimates in terms of BMI for the employed subsample are smaller than our baseline results makes an important link with the epidemiological literature. Unemployment status is known to be associated with persistence in smoking consumption and resistance to quit. For these reasons, unemployed individuals, represent a particularly interesting target group for government health promotion through anti-smoking policies (Schunck & Rogge 2010, Kriegbaum et al. 2010).

Since empirical findings have shown that gender characteristics may also lead to significant differences in smoking behavior, we report in tables 4 and 5 alternative specifications of our baseline model, in which we measure the impact of smoking habit changes for male and female sub-groups and compare them with the baseline estimates of Table 2. The smoking ban turns out to have a higher correlation with smoking habits in men: this very probably also depends on the larger numbers of Italian male smokers and the number of cigarettes they consume (Aristei & Pieroni 2010). Although column (1) of Table (5) clearly shows that women's BMI is more sensitive, leading to an increase of 0.68 unit points in the three years after the ban (0.59 from baseline model and 0.54 from male group), the causal estimates of the different specification reported in the tables remain equally distant, above and below the baseline results of Table 2, confirming the heterogeneous adverse effect on BMI. It does seem reasonable that the heterogeneous mechanisms discussed in the literature justify the greater response from men, as high participation rate or free time and income also apply in explaining gender responses to the ban argued here (see, for example Chaloupka (1992)). We discuss below the results of our model specification by gender, to explain heterogeneous changes in smoking habits in terms of body weight. We only note now that, in all previous subsample estimates, the general finding that the weight gain contribution depending almost completely on changes in quitting is confirmed.

Table 2: Causal effect of smoking on BMI

	Adults born between 1941-1989, years 2001 - 2007					**Adults born between 1943-1987, discontinuity sample**				
		Number of cigarettes		**Percentage of smokers**			**Number of cigarettes**		**Percentage of smokers**	
	BMI	Smoking	BMI	Smoking	BMI	BMI	Smoking	BMI	Smoking	BMI
	(reduced form)	(reduced form)	(structural form)	(reduced form)	(structural form)	(reduced form)	(reduced form)	(structural form)	(reduced form)	(structural form)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Smoking Ban	0.59***	-0.41***		-1.65***		0.36***	-0.44***		-2.24***	
	(0.024)	(0.062)		(0.346)		(0.040)	(0.065)		(0.367)	
Number of cigarettes			-1.45***					-0.82***		
			(0.253)					(0.169)		
Percentage of smokers					-0.36***					-0.16***
					(0.080)					(0.034)
Constant	23.85***	3.96***	29.58***	29.30***	34.31***	23.94***	4.32***	27.48***	31.87***	29.09***
	(0.050)	(0.088)	(0.943)	(0.412)	(2.268)	(0.066)	(0.136)	(0.660)	(0.639)	(1.017)
Observations	170,702	170,702	170,702	170,702	170,702	57,409	57,409	57,409	57,409	57,409
R-squared	0.21	0.05		0.03		0.21	0.05		0.03	
Adj. R-squared										

Notes: Column (1) lists estimates of reduced form in equation (2)), i.e. effect of the smoking ban in January 2005 on BMI. Columns (2) and (4) also list estimates of reduced form of effect of ban on number of cigarettes and smoking participation rate, respectively. Columns (3) and (5) list estimates of structural model from equation (4) of causal effect of smoking habits on BMI. Estimates are for 2001 - 2007 (pre-ban, 2001 - 2003; post-ban, 2005 - 2007). Columns (6)-(10) list same estimates around discontinuity introduced by ban (2003 - 2005). All estimates include covariates described in Table 1 as controls .
*Standard errors in round brackets. Significant levels reported as: p-value *** $\leq$ 0.01, ** $\leq$ 0.05, * $\leq$ 0.1.*

Table 3: Causal effect of smoking on BMI, employed adults

	Adults born between 1941-1989, years 2001 - 2007					**Adults born between 1943-1987, discontinuity sample**				
		Number of cigarettes		**Percentage of smokers**			**Number of cigarettes**		**Percentage of smokers**	
	BMI	Smoking	BMI	Smoking	BMI	BMI	Smoking	BMI	Smoking	BMI
	(reduced form)	(reduced form)	(structural form)	(reduced form)	(structural form)	(reduced form)	(reduced form)	(structural form)	(reduced form)	(structural form)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Smoking ban	0.53***	-0.55***		-2.40***		0.32***	-0.51***		-2.54***	
	(0.022)	(0.054)		(0.317)		(0.041)	(0.077)		(0.449)	
Number of cigarettes			-0.96***					-0.63***		
			(0.113)					(0.129)		
Percentage of smokers					-0.22***					-0.13***
					(0.032)					(0.026)
Constant	23.68***	4.19***	27.70***	32.59***	30.92***	23.77***	4.94***	26.88***	40.75***	28.93***
	(0.041)	(0.092)	(0.461)	(0.487)	(1.033)	(0.067)	(0.153)	(0.574)	(0.758)	(1.011)
Observations	110,559	110,559	110,559	110,559	110,559	37,280	37,280	37,280	37,280	37,280
R-squared	0.22	0.05		0.03		0.22	0.04		0.03	
Adj. R-squared										

Notes: Column (1) lists estimates of reduced form in equation (2)), i.e. effect of the smoking ban in January 2005 on BMI. Columns (2) and (4) also list estimates of reduced form of effect of ban on number of cigarettes and smoking participation rate, respectively. Columns (3) and (5) list estimates of structural model from equation (4) of causal effect of smoking habits on BMI. Estimates are for 2001 - 2007 (pre-ban, 2001 - 2003; post-ban, 2005 - 2007). Columns (6)-(10) list same estimates around discontinuity introduced by ban (2003 - 2005). All estimates include covariates described in Table 1 as controls .
*Standard errors in round brackets. Significant levels reported as: p-value *** $\leq$ 0.01, ** $\leq$ 0.05, * $\leq$ 0.1.*

Table 4: Causal effect of smoking on BMI, men

	Adults born between 1941-1989, years 2001 - 2007					Adults born between 1943-1987, discontinuity sample				
		Number of cigarettes		Percentage of smokers			Number of cigarettes		Percentage of smokers	
	BMI (reduced form)	Smoking (reduced form)	BMI (structural form)	Smoking (reduced form)	BMI (structural form)	BMI (reduced form)	Smoking (reduced form)	BMI (structural form)	Smoking (reduced form)	BMI (structural form)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Smoking ban	0.54***	-0.67***		-2.83***		0.36***	-0.65***		-2.98***	
	(0.030)	(0.093)		(0.435)		(0.039)	(0.106)		(0.540)	
Number of cigarettes			-0.80***					-0.54***		
			(0.142)					(0.120)		
Percentage of smokers					-0.19***					-0.12***
					(0.036)					(0.028)
Constant	23.60***	4.54***	27.22***	36.03***	30.44***	23.83***	5.37***	26.75***	41.43***	28.77***
	(0.048)	(0.153)	(0.547)	(0.800)	(1.151)	(0.060)	(0.196)	(0.577)	(0.925)	(1.096)
Observations	84,164	84,164	84,164	84,164	84,164	28,327	28,327	28,327	28,327	28,327
R-squared	0.12	0.03		0.02		0.13	0.03		0.03	
Adj. R-squared										

Notes: Column (1) lists estimates of reduced form in equation (2)), i.e. effect of the smoking ban in January 2005 on BMI. Columns (2) and (4) also list estimates of reduced form of effect of ban on number of cigarettes and smoking participation rate, respectively. Columns (3) and (5) list estimates of structural model from equation (4) of causal effect of smoking habits on BMI. Estimates are for 2001 - 2007 (pre-ban, 2001 - 2003; post-ban, 2005 - 2007). Columns (6)-(10) list same estimates around discontinuity introduced by ban (2003 - 2005). All estimates include covariates described in Table 1 as controls .
*Standard errors in round brackets. Significant levels reported as: p-value *** $\leq$ 0.01, ** $\leq$ 0.05, * $\leq$ 0.1.*

Table 5: Causal effect of smoking on BMI, women

	Adults born between 1941-1989, years 2001 - 2007					**Adults born between 1943-1987, discontinuity sample**				
		Number of cigarettes		**Percentage of smokers**			**Number of cigarettes**		**Percentage of smokers**	
	BMI	Smoking	BMI	Smoking	BMI	BMI	Smoking	BMI	Smoking	BMI
	(reduced form)	(reduced form)	(structural form)	(reduced form)	(structural form)	(reduced form)	(reduced form)	(structural form)	(reduced form)	(structural form)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Smoking ban	0.68***	-0.23***		-1.06***		0.36***	-0.26***		-1.65***	
	(0.032)	(0.044)		(0.313)		(0.056)	(0.066)		(0.451)	
Number of cigarettes			-2.97***					-1.41***		
			(0.581)					(0.398)		
Percentage of smokers					-0.64***					-0.22***
					(0.313)					(0.065)
Constant	21.16***	1.72***	26.29***	19.23***	33.48***	21.65***	1.12***	23.23***	14.22***	24.80***
	(0.039)	(0.048)	(0.875)	(0.353)	(3.408)	(0.095)	(0.127)	(0.336)	(0.791)	(0.842)
Observations	86,538	86,538	86,538	86,538	86,538	29,082	29,082	29,082	29,082	29,082
R-squared	0.17	0.01		0.01		0.16	0.01		0.01	
Adj. R-squared										

Notes: Column (1) lists estimates of reduced form in equation (2)), i.e. effect of the smoking ban in January 2005 on BMI. Columns (2) and (4) also list estimates of reduced form of effect of ban on number of cigarettes and smoking participation rate, respectively. Columns (3) and (5) list estimates of structural model from equation (4) of causal effect of smoking habits on BMI. Estimates are for 2001 - 2007 (pre-ban, 2001 - 2003; post-ban, 2005 - 2007). Columns (6)-(10) list same estimates around discontinuity introduced by ban (2003 - 2005). All estimates include covariates described in Table 1 as controls .
*Standard errors in round brackets. Significant levels reported as: p-value *** $\leq$ 0.01, ** $\leq$ 0.05, * $\leq$ 0.1.*

4.2 Robustness, specification checks and conditional estimations

In this section, we test for evidence that identification of the effects of smoking habits on weight gain comes from variations close to the discontinuity determined by the Italian smoking ban (Section 4.2.1). We also discuss the potential bias related to omitted variables and compare OLS estimates of average weight gain from changes in smoking habits with those obtained with IV regression (Section 4.2.2), and examine the causal effects of nicotine reduction, at different points of the BMI distribution, corresponding to specific quantiles of overweight and overweight and obese people (Section 4.2.3).

4.2.1 IDW estimations

As discussed above, the causal effects of BMI changes are predicted by changes in smoking habits (via the smoking ban) with the accuracy of implementing an estimator which measures LATEs. Note that these differences in measuring causal effects with the entire and RD samples, corresponding to periods of three years and one year before and after the discontinuity, respectively explain the relations tested in the medium and short-term for BMI and smoking habits. Clearly, the model presented in equations (2) and (3) is ensured by a predominantly identification strategy which only considers variations close to the discontinuity, so that estimates on the entire sample may be affected by trends in unobservable characteristics in different cohorts. This justifies using the IDW estimator, which assigns higher weights to those observations closer to the year of the ban. Table 6 shows the IDW estimates results. These estimates are qualitatively the same as those of Table 2, although BMI coefficients tend to decrease slightly in magnitude in absolute terms. To consider further these differences in specific sub-groups, the results for men, women and employees are reported in Appendixes A.1-A.3. For the above mentioned sub-groups, the comparison between IDW estimates and those unweighted from the whole sample are found to be even closer than those of the baseline model in Table 2. Thus, we can conclude that our identification strategy in the medium term is not significantly affected by the distance of observations from the discontinuity.

4.2.2 Endogeneity caveats and average effects on population

In contexts where causal parameters are not identified by a regression discontinuity design, the estimated relationship may be biased upwards or downwards by omitted variables. On one hand, quitters have generally been found to be less concerned about weight gain than subjects continuing to smoke. For example, Cawley et al. (2004), Rees & Sabia (2010) argue that the latter category have more self-control with respect to weight changes, so that quitters' behavior may include unobservable characteristics which overestimate the true causal effect. On the other hand, an underestimated impact on BMI increases may arise if smokers' choice to quit induces them to adopt other healthy behavior, which takes into account of general concerns about health or are more oriented towards the future, Khwaja et al. (2007). In this case, a downward bias may be produced estimating weight gains by significant positive correlations between

Table 6: Causal effect of smoking on BMI - IDW estimates

	Adults born between 1941-1989, years 2001 - 2007				
		Number of cigarettes		Percentage of smokers	
	BMI (reduced form)	Smoking (reduced form)	BMI (structural form)	Smoking (reduced form)	BMI (structural form)
	(1)	(2)	(3)	(4)	(5)
Smoking ban	0.54***	-0.40***		-1.66***	
	(0.025)	(0.059)		(0.322)	
Number of cigarettes			-1.37***		
			(0.236)		
Percentage of smokers					-0.33***
					(0.068)
Constant	23.90***	3.87***	29.21***	28.86***	33.34***
	(0.052)	(0.084)	(0.874)	(0.410)	(1.907)
Observations	170,702	170,702	170,702	170,702	170,702
R-squared	0.21	0.05		0.03	
Adj. R-squared	0.21	0.05	.	0.03	.

*Notes: Column (1) lists estimates of reduced form in equation (2)), i.e. effect of the smoking ban in January 2005 on BMI. Columns (2) and (4) also list estimates of reduced form of effect of ban on number of cigarettes and smoking participation rate, respectively. Columns (3) and (5) list estimates of structural model from equation (4) of causal effect of smoking habits on BMI. Estimates are for 2001 - 2007 (pre-ban, 2001 - 2003; post-ban, 2005 - 2007). Columns (6)-(10) list same estimates around discontinuity introduced by ban (2003 - 2005). All estimates include covariates described in Table 1 as controls . Standard errors in round brackets. Significant levels reported as: p-value *** $\leq$ 0.01, ** $\leq$ 0.05, * $\leq$ 0.1.*

smoking reductions and error terms, since being an ex-smoker for long period of time is associated with making large investments in health and well-being .

The estimates that use regression discontinuity design not only produce an impact which is expected to be unbiased, but they are expected to exceed those from OLS. As argued above, the IV estimator yields the marginal causal effect of smoking on BMI of smokers affected by the policy. Table 7 shows the estimates for smoking habits on BMI, obtained from OLS. Although smoking coefficients are significant at the conventional 1% level, the magnitude of these estimates on weight gains are really reduced with respect to the models in which the IV estimator is used. For example, in the RD sample, the impact of nicotine consumption on the BMI of the entire population falls from -0.82 to -0.015 (s.e.=0.000) with OLS estimator. As expected, this result is proportionally confirmed for the impact of the percentage of smokers. These marked differences also explain why measuring precisely the effect of smoking on weight is still considered open, and make the use of linear regression questionable (see, for example, the critical discussion of Baum (2009)).

Table 7: OLS estimates of effect of smoking on BMI

Variables	**Whole sample**	**RD sample**
Nicotine consumption	-0.015***	-0.012***
	(0.003)	(0.003)
Percentage of smokers	-0.001***	-0.001***
	(0.000)	(0.001)

*Notes: Standard errors shown in round brackets. Significant levels reported as follows: p-value *** $\leq$ 0.01, ** $\leq$ 0.05, * $\leq$ 0.1.*

4.2.3 Conditional BMI estimation: the effects for overweight and obese people

One limitation of our analysis is that nicotine effects are estimated only at the average of BMI distribution. We also want to examine other points in BMI distribution mainly for two reasons. First, estimates at different quantiles may provide an opportunity to trace smoking habit changes for portions of the overall BMI distribution. Second, in terms of welfare, we are interested in particular points of BMI distribution, because we can highlight significant differences in the magnitude of the effects for particularly interesting sub-groups of the population (e.g. obese and overweight people). Since the overweight dimension is more important than the dimension of obesity in Italy[13], we estimate the effects of smoking habits on points of the BMI distribution corresponding to the mean of the sample of overweight (OV) (77^{st} percentile) and overweight and obese (OVOB) (81^{st} percentile) individuals. We use the IV quantile treatment effect estimator, which can be obtained from the potential outcome framework (Imbens & Rubin 1997) under LATE identification assumptions. Correpsonding to these points of BMI distribution, we propose a local discontinuty quantile regression estimate based on the RD sample.

Instrumental variable estimates are shown in Table 8 for the sample means of OV and OVOB. Like the IV estimates of the average BMI, the quantile estimates for these groups have the same (negative) sign and are statistically different from zero. To help interpretation of the magnitude of these estimated effects, let us consider that the difference between OV and the sample mean effect is about -0.26 (i.e., -0.82 at the sample mean, against -0.56 for the ov group). Our estimates also suggest that including obese individuals mitigate the adverse effects of smoking habits on BMI. Estimates at the 81^{th} percentile (e.g., average of OBOV group) indicate a further reduction of the causal effect on BMI growth, attributed to nicotine decreases, measured at about 40% less than the estimated coefficient at the sample mean (from -0.82 to -0.49, respectively). Although fewer observations in the tail of our sample do not allow us to trace estimates across the obese distribution, convincing differences in the results support the validity of our main findings, in the Italian case, of a significant gain in weight through nicotine reduction in people with high BMI, although smaller when compared to the effect at the average of the sample.

It is not surprising that, more than in the full sample, almost the whole contribution to BMI increases in these subgroups depends on variations attributable to quitters. One plausible interpretation regards

[13] Note that observations above 90% percentiles are sparse. See Pieroni et al. (2011).

Table 8: Causal effect of smoking on BMI in overweight and obese individuals

	Number of cigarettes	**Percentage of smokers**
Variables	**77th (Overweight)**	**81st (Overweight and Obese)**
Nicotine consumption	-0.56***	-0.49***
	(0.067)	(0.064)
Percentage of smokers	-0.11*	-0.12*
	(0.0612)	(0.067)

Notes: Estimates obtained by instrumental variable quantile regression (IVQR). Standard errors shown in round brackets. Significant levels reported as follows:
*p-value *** $\leq$ 0.01, ** $\leq$ 0.05, * $\leq$ 0.1.*

the generally poor individual health condition of obese people, who are incentivated to stop smoking rather than to reduce cigarette consumption. We find that cuts in nicotine consumption are mainly due to quitters, although some interesting heterogeneous effects on BMI distribution emerge. First, the impact of quitting smoking on BMI is higher in the group which includes obese individuals. Second, unlike the economic literature discussed in Section 2, which focuses on empirical US analyses, we find the unexpected result of a decreasing impact of the effect of smoking on BMI for people with critical weight levels. Especially in Europe, this phenomenon has been explained by the fact that obese people may reduce their weight and smoking habits as a consequence of changes in their life-style towards better health (Brunello et al. 2011).

4.3 Body weight estimates to changes in smoking habits of smokers

We now turn to a more policy-oriented analysis of the effects of smoking reduction on weight gain. Our first results, based on the RD sample, are shown in Table 10, which lists estimates of BMI changes expressed as elasticities, making the magnitude of the smoking indicators used in our analysis more easily interpretable. The results emphasize the finding that body weight changes due to smoking reductions are attributable mostly to quitters, irrespective of whether the estimates refer to the complete sample or to subgroups of individuals. Qualitatively, these results are fully consistent with all the estimates presented above. For example, higher variations in body weight are confirmed to occur in response to smoking changes in women, and the estimated elasticity is larger than that obtained in the full sample.

Most of the estimated BMI effects seem fairly small, although there is no difficulty in achieving statistical significance at the conventional levels. However, whether or not these smoking effects are considered large enough depends on the context. To simplify this analysis, we translate the estimated effects on BMI in terms of weight, multiplying each coefficient by the squared height measured as a mean of population (or subsamples). Let us consider the implications of estimated weight changes for the Italian smoking population which was about 14,000,000 in 2005. We would expect from Figure 5 a unitary reduction in cigarette consumption to determine a rise in body weight of 3 kg, of those affected

Table 9: BMI elasticities to number of cigarettes and percentage of smokers

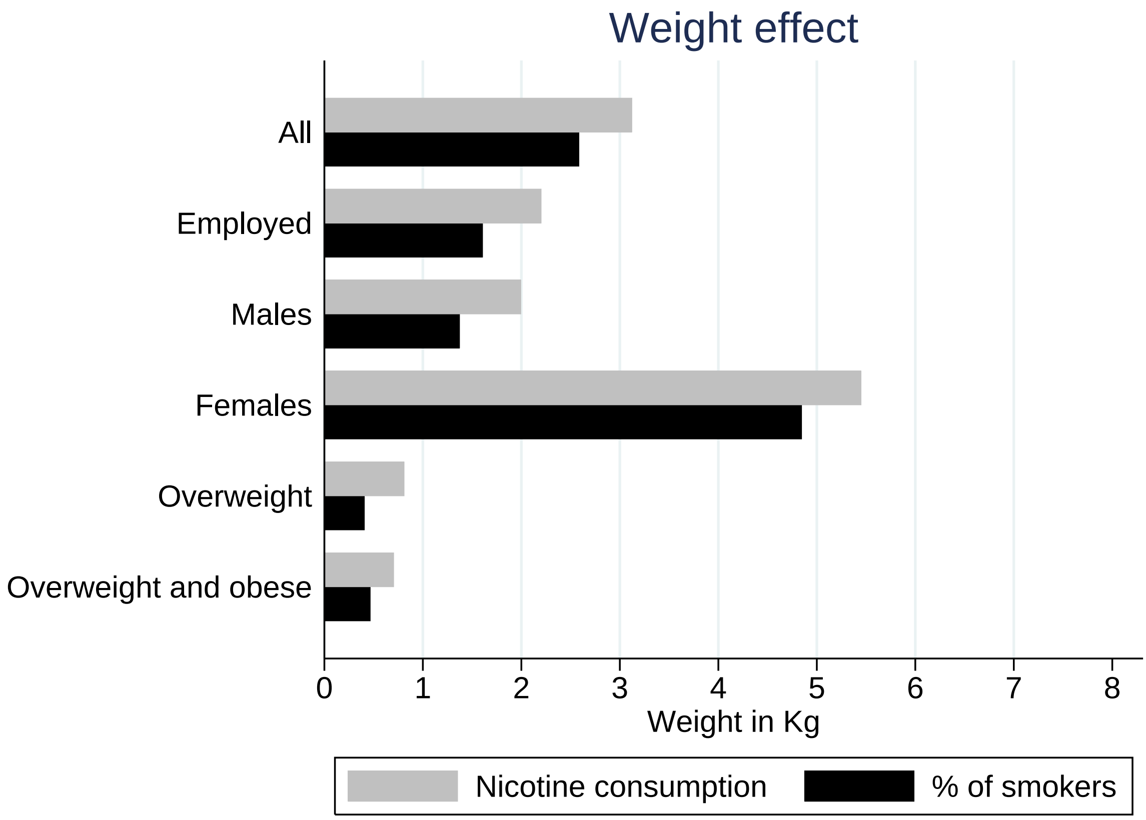
Sample	**Number of cigarettes**	**Percentage of smokers**
All subjects	-0.36***	-0.51***
	(0.062)	(0.166)
Employed	-0.23***	-0.28***
	(0.042)	(0.069)
Men	-0.31***	-0.31***
	(0.062)	(0.081)
Women	-0.43***	-0.64*
	(0.165)	(0.362)
Overweight	-0.08***	-0.11*
	(0.009)	(0.064)
Obese and Overweight	-0.06***	-0.12*
	(0.009)	(0.067)

*Notes: Standard errors shown in round brackets. Significant levels reported as follows: p-value *** $\leq$ 0.01, ** $\leq$ 0.05, * $\leq$ 0.1.*

by the smoking ban. Clearly, we estimate that more than 90% of this variation depends on the effect of quitters, implying that, in the average smoking population, the increase in weight accounts for 2.6 kg.

The estimates in Figure 5 also indicate that weight gains in employed people are lower with respect to the entire population, whereas gender differences appear to be more relevant; in addition, women's weight gains (5.6 kg) are more than double those of men (2 kg). This result can be explained by the fact that, because of reverse causality, some subjects and particularly women (see Cawley et al. (2004), Rees & Sabia (2010)) tend to use smoking to control their weight. The result listed above was also found by other studies on Italy and France (Gallus et al. 2006). Our results are inconsistent with the hypothesis, generally predicted in the economic literature, that the effects of quitting smoking are greater in obese subjects. Overweight (or overweight and obese people) appear to respond poorly to changes in nicotine consumption, although this finding matches the results of Fang et al. (2009) for China and Flegal (2007) for the United States.

Although reductions in smoking may theoretically not be desiderable, particularly if weight gains are large and have high social costs that offset the benefits of quitting, the estimates are reassuring for Italy. The limited effect on weight changes in the groups at ''weight risk" leads to predict that future policies implementing cuts in smoking should maintain limited the cost in terms of health losses paid in order to achieve smoking reforms, even if the Italian patterns of overweight and obesity are increasing.



Notes: Lighter bars: weight changes of nicotine consumption; darker bars: impact of quitters only. Effect on weight of nicotine consumption and percentage of smokers was retrieved multiplying coefficients obtained from RD estimates reported in columns 8 and 10 of each sample by squared height. To compare change in BMI unit points, estimated coefficient of percentage of smokers was multiplied by inverse of fraction of smokers (see details in Section 4.1).

Figure 5: Causal effect of smoking on weight. Discontinuity sample

5 Conclusions

A long-standing prediction in health economics is that body weight gains may be partly explained by reduced nicotine consumption. In practice, this trade-off is highly dependent on smokers' response, which may be controlled by policy interventions. This is because a practical way of discouraging smoking is to implement severe anti-smoking laws, which ''*coeteris paribus*'' will raise the individual opportunity cost of smoking, and affect specific smokers' groups differently. In addition some papers have recently questioned the significance of this relationship. This is based on the evidence that nicotine reduction is often linked with unobserved individual health, which may affect causal estimates of smoking on body weight upward or downward. More importantly, these correlation biases may differently affect socio-economic groups or groups of interest for public health, i.e., overweight and obese.

Learning about the effects of smoking habits on weight gains requires a setting which generates an exogenous variation in future outcomes. The 2005 Italian Clean Indoor Air Law generates such a variation and is the background for our research design. With this law, individuals of the same age, but born in adjacent birth-cohorts face different smoking restrictions in public places.

With this approach, we find that smokers significantly respond to the smoking ban, giving rise to sudden negative changes in cigarette consumption. We attempt to estimate the magnitudes of smoking habit changes on weight with a simplified structural model. We require the data to be accommodated to estimate this impact over a ex-post period of three years (2005-2007) by an IV whole sample approach, which we compare with an RD design able to assess nicotine reduction on BMI in a post-period of one year. As a general result, the baseline models predict a large impact in terms of BMI changes with the shortest horizons of the RD sample: an increase of 0.82 in BMI with respect to a unitary decrease of 1 cigarette in the smoker population is proportionally greater than the increase in BMI 1.45 in three years obtained from the entire sample. A caveat to this general conclusion involves the specific estimates for employed individuals and for men and women. Although the exogenous shock impact of the smoking ban on men and employees has very large adverse effects on smoking habits, weight gains are smaller than those at the mean of the population whereas women tend to gain weight largely in response to reductions in cigarette consumption.

We also conclude that a decreasing smoking participation rate or cigarette consumption has limited effects in weight gains in both overweight and overweight and obese people. With respect to the literature, we favor a less restrictive explanation of these findings: that of a decreasing causal impact of nicotine reductions over the BMI distribution, which causes a corresponding very small weight gain. In these important respects, our results show that anti-smoking policies, generally favored by society, may not play a role in increasing the cost of overweight and obesity, when we look towards the future.

References

Abbring, J. H. & Heckman, J. J. (2007), Chapter 72 econometric evaluation of social programs, part iii: Distributional treatment effects, dynamic treatment effects, dynamic discrete choice, and general equilibrium policy evaluation, Vol. 6, Part B of *Handbook of Econometrics*, Elsevier, pp. 5145 – 5303.

Adda, J., Bashkar, V., Berlinski, S. & Machin, S. (2012), 'Market regulation and firm performance: The case of smoking bans in the uk', *Journal of Law and Economics* **forthcoming**.

Adda, J. & Cornaglia, F. (2010), 'The effect of bans and taxes on passive smoking', *American Economic Journal: Applied Economics* **2**(1), 1–32.

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

Anonymous (2005), 'Ireland's smoking ban is an admirable achievement', *Lancet* (365), 1282.

Aristei, D. & Pieroni, L. (2010), 'Habits, complementarities and heterogeneity in alcohol and tobacco demand: A multivariate dynamic model', *Oxford Bulletin of Economics and Statistics* **72**(4), 428–457.

Baker, M., Gruber, J. & Milligan, K. (2008), 'Universal child care, maternal labor supply, and family well-being', *Journal of Political Economy* **116**(4), 709–745.

Barefoot, J., Heitmann, B., Helms, M., Williams, R., Surwit, R. & Siegler, I. (1998), 'Symptoms of depression and changes in body weight from adolescence to mid-life.', *International Journal of Obesity Related Metabolic Disorders.* **22**(7), 688–694.

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

Becker, G. S. & Murphy, K. M. (1988), 'A theory of rational addiction', *Journal of Political Economy* **96**(4), 675–700.

Brunello, G., Fort, M., Schneeweis, N. & Winter-Ebmer, R. (2011), The causal effect of education on health: What is the role of health behaviors?, Economics working papers 2011-17, Department of Economics, Johannes Kepler University Linz, Austria.

Cawley, J., Markowitz, S. & Tauras, J. (2004), 'Lighting up and slimming down: the effects of body weight and cigarette prices on adolescent smoking initiation', *Journal of Health Economics* **23**(2), 293–311.

Chaloupka, F. (1992), 'Clean indoor air laws, addiction and cigarette smoking', *Applied Economics* **24**, 193–205.

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

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.

Cinciripini, P., Wetter, D., Fouladi, R., Blalock, J., Carter, B., Cinciripini, L. & Baile, W. (2003), 'The effects of depressed mood on smoking cessation: mediation by postcessation self-efficacy.', *Journal of Consulting and Clinical Psychology.* **71**(2), 292–301.

Colombo, P., Scarpino, V., Zuccaro, P., Apolone, G., Gallus, S. & La Vecchia, C. (2002), 'Smoking in italian women and men, 2001', *Tumori* **88**, 10–12.

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

Cutler, D. M. & Glaeser, E. L. (2009), Why do europeans smoke more than americans?, *in* 'Developments in the Economics of Aging', NBER Chapters, National Bureau of Economic Research, Inc, pp. 255–282.

Deaton, A. (1985), 'Panel data from time series of cross-sections', *Journal of Econometrics* **30**(1-2), 109–126.

Dill, D., Edwards, H. & Forbes, W. (1934), 'Tobacco smoking in relation to blood sugar, blood lactic acid and metabolism', *Am J Physiol* **109**, 118–22.

Drewnowski, A. & Darmon, N. (2005), 'Food choices and diet costs: an economic analysis', *Journal of Nutrition* **135**, 900–904.

Eisenberg, D. & Quinn, B. (2006), 'Estimating the causal effect of smoking cessation on weight gain: An instrumental variables approach.', *Health Services Research* **41**(6), 2255–2266.

Eriksen, M. & Chaloupka, F. (2007), 'The economic impact of clean indoor air laws', *A Cancer Journal for clinicians* **57**(6), 367–378.

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

Fang, H., Ali, M. M. & Rizzo, J. A. (2009), 'Does smoking affect body weight and obesity in china?', *Economics & Human Biology* **7**(3), 334–350.

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

Flegal, K. (2007), 'The effects of changes in smoking prevalence on obesity prevalence in the united states', *American Journal of Public Health* **97**, 1510–1514.

Fong, G., Hyland, A., Borland, R., Hammond, D., Hastings, G., McNeill, A., Anderson, S., Cummings, K., Allwright, S., Mulcahy, M., Howell, F., Clancy, L., Thompson, M., Connolly, G. & Driezen, P.

(2006), 'Reductions in tobacco smoke pollution and increases in support for smoke-free public places following the implementation of comprehensive smoke-free workplace legislation in the republic of ireland: findings from the itc ireland/uk survey', *Tobacco Control* **15**, 51–58.

French, S. & Jeffery, R. (1995), 'Weight concerns and smoking: a literature review', *Annals of Behavioral Medicine* **17**, 234–244.

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.

Garcia, J. & Labeaga, J. M. (1996), 'Alternative approaches to modelling zero expenditure: An application to spanish demand for tobacco', *Oxford Bulletin of Economics and Statistics* **58**(3), 489–506.

Glauser, S., Glauser, E., Reidenberg, M., Rusy, B. & Tallarida, R. (1970), 'Metabolic changes associated with the cessation of cigarette smoking', *Arch Environ Health* **20**(1), 377–81.

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

Grunberg, N. (1985), 'Nicotine, cigarette smoking, and body weight', *British Journal of Addiction* **80**, 369–377.

Hahn, J., Todd, P. & Van der Klaauw, W. (2001), 'Identification and estimation of treatment effects with a regression-discontinuity design', *Econometrica* **69**(1), 201–09.

Havnes, T. & Mogstad, M. (2010), Is universal child care leveling the playing field? evidence from non-linear difference-in-differences, IZA Discussion Papers 4978, Institute for the Study of Labor (IZA).

Heckman, J. J., Flyer, F. & Loughlin, C. (2008), 'An assessment of causal inference in smoking initiation research and a framework for future research', *Economic Inquiry* **46**(1), 37–44.

Heckman, J. J. & Vytlacil, E. J. (2007), Chapter 71 econometric evaluation of social programs, part ii: Using the marginal treatment effect to organize alternative econometric estimators to evaluate social programs, and to forecast their effects in new environments, Vol. 6, Part B of *Handbook of Econometrics*, Elsevier, pp. 4875 – 5143.

Higgins, M.W.and Kjelsberg, M. (1967), 'Characteristics of smokers and nonsmokers in tecumseh, michigan', *American Journal of Epidemiology* **86**, 60–77.

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

Imbens, G. W. & Rubin, D. B. (1997), 'Estimating outcome distributions for compliers in instrumental variables models', *Review of Economic Studies* **64**(4), 555–74.

Jacobs, D. & Gottenberg, S. (1981), 'Smoking and weight: The minnesota lipid research clinic', *American Journal of Public Health* (71), 391–396.

Jacobs, M., Knapp, P., Anderson, L., Karnsh, N., Meissner, R. & Richman, S. (1965), 'Relationship of oral frustration factors with heavy cigarette smoking in male college students.', *J Nerv Ment Dis* **141**, 161–171.

Jones, A. M. & Yen, S. T. (2000), 'A box-cox double-hurdle model', *Manchester School* **68**(2), 203–21.

Juster, H., Loomis, B., Hinman, T. & et al. (2007), 'Declines in hospital admissions for acute myocardial infarction in new york state after implementation of a comprehensive smoking ban.', *Am J Public Health* **97**(11), 2035–2039.

Kapteyn, A., Alessie, R. & Lusardi, A. (2005), 'Explaining the wealth holdings of different cohorts: Productivity growth and social security', *European Economic Review* **49**(5), 1361–1391.

Karvonen, M., Keys, A., Orma, E., Fidanzo, F. & Brozek, J. (1959), 'Cigarette smoking, serum cholesterol, blood pressure and body fatness: observations in finland.', *Lancet* **1**, 492–494.

Keane, M. P., Todd, P. E. & Wolpin, K. I. (2011), Chapter 4 - the structural estimation of behavioral models: Discrete choice dynamic programming methods and applications, *in* O. Ashenfelter & D. Card, eds, 'Handbooks in Economics Handbook of Labor Economics, Vol 4A', Vol. 4, Part A of *Handbook of Labor Economics*, Elsevier, pp. 331 – 461.

Keys, A., Aravanis, C. & Blackburn, H. (1966), 'Epidemiologic studies related to coronary heart disease: characteristics of men aged 40-59 in seven countries', *Acta Med Scand Suppl* **460**, 1–75.

Khwaja, A., Silverman, D. & Sloan, F. (2007), 'Time preference, time discounting, and smoking decisions', *Journal of Health Economics* **26**(5), 927–949.
URL: *http://ideas.repec.org/a/eee/jhecon/v26y2007i5p927-949.html*

Klesges, R., Meyers, A., Klesges, L. & LaVasque, M. (1989), 'Smoking, body weight, and their effects on smoking behavior: a comprehensive review of the literature', *Psychology Bulletin* **106**, 204–230.

Kriegbaum, M., Larsen, A., Christensen, U., Lund, R. & Osler, M. (2010), 'Reduced probability of smoking cessation in men with increasing number of job losses and partnership breakdowns.', *J Epidemiol Community Health* (55), 271–278.

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.

Luk, R., Ferrence, R. & Gmel, G. (2011), 'The economic impact of a smoke-free bylaw on restaurant and bar sales in ottawa, canada', *Addiction* (101), 738–745.

Machin, S., Marie, O. & Vujic, S. (2011), 'The crime reducing effect of education', *Economic Journal* **121**(552), 463–484.

Nonnemaker, J., Finkelstein, E., Engelen, M., Hoerger, T. & Farrelly, M. (2009), 'Have efforts to reduce smoking really contributed to the obesity epidemic?', *Economic Inquiry* **47**(2), 366–376.

Oreopoulos, P. (2006), 'Estimating average and local average treatment effects of education when compulsory schooling laws really matter', *American Economic Review* **96**(1), 152–175.

Pieroni, L., Lanari, D. & Salmasi, L. (2011), 'Food prices and overweight patterns in italy', *The European Journal of Health Economics* pp. 1–19. 10.1007/s10198-011-0350-y.

Rees, D. I. & Sabia, J. J. (2010), 'Body weight and smoking initiation: Evidence from add health', *Journal of Health Economics* **29**(5), 774–777.

Sargent, R., Shepard, R. & Glantz, S. (2004), 'Reduced incidence of admissions for myocardial infarction associated with public smoking ban: before and after study.', *BMJ* **328**, 977.

Schunck, R. & Rogge, B. (2010), 'Unemployment and its association with health-relevant actions: investigating the role of time perspective with german census data.', *International Journal of Public Health* (55), 271–278.

Scollo, M., Lal, A. & Glantz, S. (2003), 'Review of the quality of studies on the economic effects of smoke-free policies on the hospitality industry', *Tobacco Control* **12**, 13–20.

Tauras, J. A. (2005), 'An empirical analysis of adult cigarette demand', *Eastern Economic Journal* **31**(3), 361–375.

Trochim, W. (1984), 'Research design for program evaluation.', *Beverly Hills: Sage Publications.* .

Trochim, W. (2001), 'Regression discontinuity design.', *International Encyclopedia of the Social and Behavioral Sciences* **19**, 12940–12945.

Trochim, W. & Campbell, D. (1960), 'Regression-discontinuity analysis: An alternative to the ex-post facto design.', *Journal of Educational Psychology* **51**, 309–317.

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

US Department of Health and Human Services (2006), '2006 surgeon general's report on the health consequences of involuntary exposure to tobacco smoke', *DHHS Publication CDC* (90-8416).

Viscusi, W. K. & Hersch, J. (2001), 'Cigarette smokers as job risk takers', *The Review of Economics and Statistics* **83**(2), 269–280.

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

Wurtman, J. (1993), 'Depression and weight gain: the serotonin connection.', *International Journal of Obesity Related Metabolic Disorders.* **29**(2-3), 183–192.

Yen, S. (2005), 'Zero observations and gender differences in cigarette consumption', *Applied Economics* **37**(16), 1839–1849.

Yurekli, A. & Zhang, P. (2000), 'The impact of clean indoor air laws and cigarette smuggling on demand for cigarettes: an empirical model', *Health Economics* **9**, 159–170.

APPENDIX A

Table A.1: Causal effect of smoking on BMI, employed adults - IDW estimates

	Adults born between 1941-1989, years 2001 - 2007				
		Number of cigarettes		**Percentage of smokers**	
	BMI (reduced form)	Smoking (reduced form)	BMI (structural form)	Smoking (reduced form)	BMI (structural form)
	(1)	(2)	(3)	(4)	(5)
Smoking ban	0.48***	-0.54***		-2.39***	
	(0.023)	(0.051)		(0.288)	
Number of cigarettes			-0.89***		
			(0.104)		
Percentage of smokers					-0.20***
					(0.027)
Constant	23.73***	4.08***	27.37***	32.14***	30.24***
	(0.042)	(0.095)	(0.417)	(0.492)	(0.853)
Observations	110,559	110,559	110,559	110,559	110,559
R-squared	0.22	0.05		0.03	
Adj. R-squared	0.22	0.04	.	0.03	.

Notes: Notes: see, Table 6.

Table A.2: Causal effect of smoking on BMI, men - IDW estimates

	Adults born between 1941-1989, years 2001 - 2007				
		Number of cigarettes		**Percentage of smokers**	
	BMI (reduced form)	Smoking (reduced form)	BMI (structural form)	Smoking (reduced form)	BMI (structural form)
	(1)	(2)	(3)	(4)	(5)
Smoking ban	0.49***	-0.64***		-2.73***	
	(0.029)	(0.090)		(0.416)	
Number of cigarettes			-0.77***		
			(0.137)		
Percentage of smokers					-0.18***
					(0.034)
Constant	23.66***	4.52***	27.13***	35.74***	30.14***
	(0.046)	(0.149)	(0.546)	(0.808)	(1.098)
Observations	84,164	84,164	84,164	84,164	84,164
R-squared	0.12	0.03		0.02	
Adj. R-squared	0.12	0.03	.	0.02	.

Notes: see, Table 6.

Table A.3: Causal effect of smoking on BMI, women - IDW estimates

	Adults born between 1941-1989, years 2001 - 2007				
		Number of cigarettes		**Percentage of smokers**	
	BMI (reduced form)	Smoking (reduced form)	BMI (structural form)	Smoking (reduced form)	BMI (structural form)
	(1)	(2)	(3)	(4)	(5)
Smoking ban	0.62***	-0.23***		-1.16**	
	(0.034)	(0.042)		(0.297)	
Number of cigarettes			-2.68***		
			(0.484)		
Percentage of smokers					-0.54***
					(0.135)
Constant	21.21***	1.75***	19.47***	25.91***	31.68***
	(0.043)	(0.087)	(0.046)	(0.736)	(2.473)
Observations	86,932	86,932	86,932	86,932	86,932
R-squared	0.16	0.01		0.01	
Adj. R-squared	0.16	0.01	.	0.01	.

Notes: see, Table 6.