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

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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 due to smoking restrictions 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 significant, although small, effect of quitting on weight increases. Heterogeneous effects of smoking cessation on weight gains are also estimated with respect to the mean distribution of BMI, with a smaller impact on men, employees, and 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 fallen consistently in the last few decades in both the US and Europe. While it is already established that smoking reductions have positive effects on individuals health, some academic research has shown that they may also be responsible for unintended negative consequences, like weight increases. In this paper, we follow this line of research and focus on estimating the causal relationship of smoking on body weight by exploiting the Clean Indoor Air Law (CIAL), implemented in Italy as from 10 January 2005, which has been demonstrated to be effective in reducing significantly both numbers of smokers and average cigarette consumption (Federico et al. 2012). As discussed in section 2, previous literature findings show that CIALs are effective in limiting exposure to smoke by non-smokers (i.e., passive smoking), with evident benefits on the prevalence of some types of cancer and cardiovascular diseases.

Section 3 presents the empirical strategy adopted in our analysis. Under the assumption that the smoking ban increased the individual cost of smoking, our strategy exploits the discontinuity introduced on smoking habits to estimate the reaction in terms of BMI, unobserved confounders being netted out. This empirical strategy overcomes the common problem of examining the effect of smoking on weight by means of reduced-form models by estimating a structural model based on more appealing theoretical foundations. For model identification, we take advantage of the fact that individuals of the same age but born in adjacent cohorts, undergo different types of smoking restrictions. We assume that, although all other determinants of smoking may vary in time, they should not have changed discontinuously in 2005. The descriptive sub-section motivates our paper empirically. In particular, we use the ''Everyday Life Aspects" (ELA), a representative sample of micro-data for Italy, to show the discontinuity introduced by the clean indoor air law, on smoking habits and BMI (i.e., the key variables of our model).

In section 4, we estimate the empirical predictions of our model with an instrumental variables (IV) approach, on a sample of observations collected around the discontinuity (i.e., IV sample, years from 2001 to 2007). We also adopt a regression discontinuity (RD) approach, in which we use only the observations collected in the years immediately before and after the smoking ban came into force (i.e., IV-RD sample, years 2003 and 2005) to estimate model parameters. Note that, while estimates carried out on the IV-RD sample include a set of covariates, such as age, age squared, cohort dummies and regional dummies, those obtained from the IV sample also include specific regional time trends, in order to account for the effect of unobservable variables which may have affected BMI and smoking habits, in addition to observable characteristics during the period of analysis.

We first show that the smoking ban explains the variability of the key variables of our model around the discontinuity using both IV-RD and IV samples. The estimated parameters were found to be very similar among each sample, meaning that time and regional trends efficiently capture unobserved smoking and BMI dynamics. These findings are confirmed even when we use an inverse distance weight (IDW) estimator. Our empirical results also indicate that quitting smoking accounts for almost the entire variability in weight changes, while cigarette consumption reductions are not responsible for significant variations in body weight.

Comparing our results by working status, gender, and weight risk individuals such as overweight and obese people, we also examine the hypothesis that changes in smoking habits lead to heterogeneous impacts on weight. We estimate that post-ban smoking changes for employed individuals produce lower responses on BMI, whereas a larger effect was estimated for the group of women. Our estimates on i) overweight and ii) overweight and obese individuals, indicate positive and significant BMI variations, although smaller than those estimated at the mean of the sample. We also calculated the effects of smoking on body weight, obtained by multiplying the estimated BMI variation by the square of the average height of each sample, and found that a unitary reduction in cigarette consumption led to an increase of about 1 kg in the IV sample, although most of the variation (0.9 kg) was due to quitting. Estimates carried out by working status and gender indicate a significant reduction in the smoking habits in each subgroup, although weight variations were found to be close to those of the entire sample. In addition, weight increases in overweight and obese individuals were estimated to be small and do not exceed 0.7 kg, a reassuring result for policy-makers concerned with the application of anti-smoking policies in the near future.

Section 5, presents the results of several robustness checks. First, we examined whether the inclusion of trends specific to the region of residence or differences in other time-varying factors could bias our results. Second, we performed a placebo test for the location of the discontinuity, to evaluate whether the effect estimated from our model was a real effect of the anti-smoking law and not due to the negative correlation between BMI and smoking time trends. Third, since our dataset allowed us to distinguish among current, former, and never smokers, we used a Difference-in-Differences (DID) approach in order to test the hypothesis that weight variations in the post-ban period are associated with current or former smokers, (i.e., individuals whose smoking habits were affected by the smoking ban). Then we tested whether this estimated variation was in line with the results obtained through RD. The estimates from the robustness analysis were close to those from the baseline model, providing evidence that our empirical strategy produces unbiased estimates of the causal effect of smoking on body weight. Section 6 concludes.

2 Related literature

In this section, we briefly describe the literature on the effects of anti-smoking laws on smoking habits and the unintended consequences on body weight of reducing smoking or quitting completely.

2.1 Clean indoor air laws: direct effects on smoking habits

Although isolated examples of policies restricting smoking had been recorded earlier, the 1973 law in Arizona was the first state intervention achieving smoke-free aims in public places. This law stated 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, followed the suggestions of the Surgeon General's Report[1], which emphasized the adverse health effects of passive smoking on public health.

As demonstrated by various 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 written by Chaloupka & Saffer (1992). These authors, as well as Evans et al. (1999), emphasized the result that, while prohibiting smoking at the workplace was effective in reducing

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

prevalence and consumption, these effects were much smaller when restrictions were only introduced in public places.

With the exception of Finland[2], European CIALs are relatively recent. In a survey conducted in Ireland after the 2004 introduction of smoke-free legislation, Anonymous (2005) and Fong et al. (2006) found that the law helped 80% of smokers to quit succesfully. Evaluating the 2005 Italian law for smoke-free public places, Gallus et al. (2006) estimated that smoking prevalence decreased by 1.9% between 2004 and 2005 and that the daily number of cigarettes decreased by 9.5%[3]. These results are in line with those found in other countries, such as the USA, Australia, Canada and Germany (Fichtenberg & Glantz 2004). However, with some exceptions, differences by gender and working status have often been disregarded in the literature on smoke-free legislations. Chaloupka (1992) found that CIALs in the US were more effective for men, given their higher labor participation rates, with respect to women. Gallus et al. (2006) showed that the accelerating decline in men's smoking rates in Italy was partly attributable to the 2005 legislation, which banned smoking in all indoor public places. In relation to work status heterogeneity, Glasgow et al. (1997) estimated that employees who worked in a smoke-free workplace were over 25% more likely to make serious attempts to quit smoking, and over 25% were also more likely to quit successfully than those who worked in a workplace where smoking was allowed. In addition, among smokers, employees in smoke-free workplaces consumed on average about three cigarettes per day less than those who worked in places with non-restrictive smoking policies. These results were confirmed in subsequent studies evaluating anti-smoking policies in Canada (Bauer et al. 2005) and Finland (Helakorpi et al. 2007).

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. Quitting smoking may increase body weight because changes in nicotine consumption produce effects on human metabolism. As discussed in Karvonen et al. (1959), Keys et al. (1966) and Higgins (1967), the observed weight increase recorded after

[2] The Finnish Tobacco Control Act (TCA) was implemented in 1976.

[3] Gallus et al. (2006) also found that the reduction in smoking prevalence and intensity was particularly strong in younger generations.

quitting does not generally turn out to be very large. In particular, Grunberg (1985), Klesges et al. (1989) and French & Jeffery (1995) noted that the weight gap between smokers and non-smokers was entirely due to differences in metabolic rates among these groups, due to the higher quantity of calories burned during the day by smokers. 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)).

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). This may imply that preferences may also change with a larger propensity to move toward unhealthy food, which usually has higher calorie contents (Drewnowski & Darmon 2005). Conversely, psychiatric studies have shown that quitters also tend to be less depressed and exhibit fewer negative effects when they quit successfully than subjects who continue to smoke (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 quitting (or reducing) smoking causes weight gains. As a special focus, these works evaluated this relationship in the obese sub-group, given the potential consequences in terms of costs for national health services. However, these studies provide different effects depending on methodology and the model specifications used to produce estimates. Chou et al. (2004) estimated a positive relationship between cigarette prices and body weight among adults using the Behavioral Risk Factor Surveillance System (BRFSS), indicating that a decrease in smoking was responsible for increased obesity rates. With the same dataset, Gruber & Frakes (2006) found an adverse relationship between cigarette taxes and BMI, with non-significant effects on obesity. The limitation which emerges from these studies is that the relationship between individual smoking behaviors and weight changes, identified through cigarette prices and taxes, may also be influenced by endogeneity. Cigarette taxes may fail to incorporate exogenous state variation (for example, the cost of production), whereas cigarette prices are potentially endogenous because they are partially determined by cigarette demand; in this case, states where cigarette demand is high may tend to invest less in health and have more obesity. Baum (2009) used these arguments to propose an identification strategy of the effects of the cost of cigarettes based on the comparison between weight variations of a treatment group exposed to higher cigarette costs, with weight variations of a comparison group unaffected by cigarette cost variations. This strategy adopts a *Difference-in-Differences* estimator on a cohort of young adults aged between 14 and 21 years extracted from the BRFSS. Baum (2009) found that both cigarette taxes and prices had positive effects on BMI and obesity prevalence.

Instead, another strand of the literature examined the direct effect of smoking habit changes on body weight by applying individual smoking indicators, instead of cigarette prices or taxes at regional level. Fang et al. (2009) found a negative relationship between cigarette consumption and BMI in China, but this effect was estimated to be insignificant for obese individuals.

The importance of this debate is made even more striking by the fact that there still is no agreement on the magnitude of smoking-related weight variations. The meta-analysis of Klesges et al. (1989), showed that the estimated weight gains ranged from 0.2 to 8.2 kg and were mainly explicated in the short term. In particular, six months after quitting, body weight increased on average between 2 and 5 kg. Another important result shown by Courtemanche (2009) highlighted the fact that, although weight variations were generally small in the short term, significant long-term reductions in former smokers' body weight were observed.

Recently, this literature has also proposed identifying the effect of smoking habit changes on weight by exploiting the application of the CIALs. Liu et al. (2010) employed workplace smoking bans at state level in the US as an instrument for smoking. With data from the BRFSS for the years 1998-2006, the authors found that, when compared with IV estimates, OLS underestimated the effect of smoking on the BMI both of the entire population and of obese individuals. The idea that we share with that study is to use the discontinuity introduced by the smoking ban in Italy as a natural instrument because it is enforced by the state, and produces a purely exogenous variation on individual smoking habits.

3 Framework of analysis

We focus here on the need to draw causal estimates of the effect of smoking on weight changes, isolating the effect of smoking from other confounding factors which may also affect BMI. We justify the use of the regression-discontinuity design in sub-section 3.2 from the evidence of significant differences in BMI and smoking habits before and after the no-smoking law came into force in Italy.

3.1 A model for the causal relationship between smoking and BMI

Estimating the magnitude of the causal effect of smoking on weight is a non-trivial challenge. Many empirical studies have documented a negative association between cigarette consumption and BMI, although it is not clear what portion of this expected increase may be attributed to smoking reductions (Nonnemaker et al. 2009).

At this stage, we write a simple reduced-form equation for a direct estimate of the effect of smoking (S_{it}) on body mass index (BMI_{it}) for each individual i at time t. That is:

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

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

Identification of the causal effect requires being able to control for unobserved 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 their smoking behavior, then least-square estimates (OLS) of γ_1 will be biased. Again, γ_1 may be estimated to be negative, although smoking variable S may have no causal effect on BMI. For instance, one would expect 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 there is no causal effect between these two variables.

We use an IV estimator within a regression discontinuity design[4] to estimate the parameters of interest, in which the 2005 Clean Indoor Air Law, which prohibits smoking in public workplaces, restaurants, bars, and cafés,is used to instrument smoking habits. 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 1 for individuals interviewed after the introduction of the smoking ban and 0 for individuals of the same age interviewed before it. The reduced-form specifications for smoking variables and BMI are:

$$\begin{aligned} BMI_{it} =& \beta_0 + \beta_1 SB + \beta_2 age_i + \beta_3 age_i^2 + \sum_{c=1}^{C} \lambda_c^1 D_c + \beta_4 trend + \beta_5 trend_i^2 + \sum_{r=1}^{R} \nu_r^1 D_r \\ &+ \sum_{r=1}^{R} \varpi_r^1 (trend \times D_r) + \sum_{r=1}^{R} \rho_r^1 (trend^2 \times D_r) + \sum_{j=1}^{J} \omega_j^1 X_{jit} + u_{it} \end{aligned} \tag{2}$$

and

$$\begin{aligned} S_{it} =& \delta_0 + \delta_1 SB + \delta_2 age_i + \delta_3 age_i^2 + \sum_{c=1}^{C} \lambda_c^2 D_c + \delta_4 trend + \delta_5 trend_i^2 + \sum_{r=1}^{R} \nu_r^2 D_r \\ &+ \sum_{r=1}^{R} \varpi_r^2 (trend \times D_r) + \sum_{r=1}^{R} \rho_r^2 (trend^2 \times D_r) + \sum_{j=1}^{J} \omega_j^2 X_{jit} + \upsilon_{it}. \end{aligned} \tag{3}$$

We then follow the structural model proposed by Machin et al. (2011)[5] to derive BMI causal estimates. Formally, this is given as:

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

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

$$
\begin{aligned}
BMI_{it} =& \theta_0 + \theta_1 S_{it} + \theta_2 age_i + \theta_3 age_i^2 + \sum_{c=1}^{C} \lambda_c D_c + \theta_4 trend + \theta_5 trend_i^2 + \sum_{r=1}^{R} \nu_r D_r \\
&+ \sum_{r=1}^{R} \varpi_r (trend \times D_r) + \sum_{r=1}^{R} \rho_r (trend^2 \times D_r) + \sum_{j=1}^{J} \omega_j X_{jit} + \upsilon_{it},
\end{aligned} \tag{4}
$$

where the IV estimate of the effect of smoking on BMI is expressed in equation (4) as 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 who modify their smoking choices (quitters or reducers after the ban), because they react to the instrument (i.e., the smoking ban), and this allows us to obtain causal estimates of BMI by the local average treatment effect (LATE)[6].

The model presented in equation (4) also controls for: first, differences in observable individual characteristics, which may affect BMI and smoking habits, by including the vector of control variables X_{jit}; this vector accounts for gender, education, marital status, employment status, physical activity and job strenuousness (see Table 1, for detailed descriptive statistics). Second, to limit the effect of unobserved heterogeneity, the empirical specification also includes cohort dummies (D_c) and a quadratic polynomial in age (age and age^2). A second-order polynomial time trend ($trend$ and $trend^2$) is included to account for the effects of changes in technology, (Lakdawalla et al. 2005), life-style (Chou et al. 2004) and/or food consumption (Zheng & Zhen 2008, Pieroni et al. 2011). In this way we avoid the possibility that, estimates of the smoking ban effect also pick up those of other BMI or smoking determinants. As argued in Gallus et al. (2006), time-varying regional confounders may heterogeneously affect BMI and smoking behavior, because of differences in culture, tradition, eating and drinking and environment. To account for this point, we add a full set of regional dummies (D_r) and non-linear regional time trends ($D_r \times trend$ and $D_r \times trend^2$) to our specification in the IV sample, but only include regional dummies when we use the IV-RD sample, because in this case trend variables are perfectly collinear with the smoking ban dummy.

[6]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 by the Italian Institute of Statistics (ISTAT). This 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.

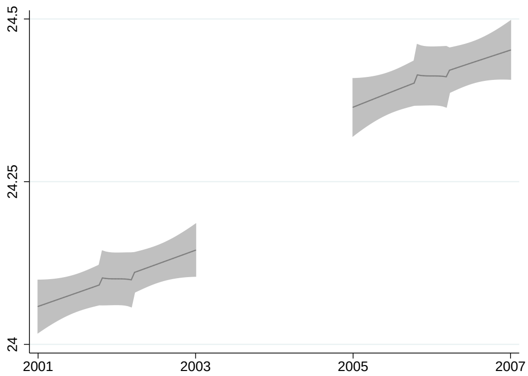
For the aims of the present study, the importance of the ELA survey lies in the detailed section devoted to analysis of current and past smoking habits of individuals aged 18 and over. In particular, we focus on individual smoking behavior, in terms of both participation rate and cigarette consumption. We used six rounds of the survey, corresponding to the years 2001-2007 (except 2004, for which data were not available). The IV sample includes individuals aged from 20 to 60 years in the pre-ban period (2001-2003), and compares them with individuals of the same age in the post-ban period (2005-2007). We consider two different indicators of smoking habits: the average number of cigarettes smoked daily, and the smoking participation rate, with the aim of examining the effect of cigarette consumption reductions and quitting smoking, respectively.

To guarantee that we are correctly estimating the causal effect of smoking on BMI by the RD design, one condition is that variation of our model's key variables is not null around the discontinuity (Hahn et al. 2001, Oreopoulos 2006). Unfortunately, as previously stated, the ELA survey was not conducted in 2004; we descriptively overcome this lack of information, at least for smoking habits and BMI, by looking at data from other sources. Our aim is to show that smoking habits did not change significantly between 2003 and 2004, whereas they did between 2004 and 2005, and that this variation is close to our estimate. There are at least other two sources that we can use to proxy smoking behavior in 2003 and 2004. One is the total number of cigarettes sold, figures provided by the Italian Ministry of Health, which shows that cigarette sales decreased by 6.1% between 2004 and 2005, a variation three times larger than that which occurred between 2003 and 2004. The second source is a survey conducted yearly by DOXA, which collects a large set of information about smoking habits for a sample of about 3000 individuals. In a paper on the evaluation of the clean indoor air law in Italy, Gallus et al. (2006) showed that, between 2004 and 2005, there were significant reductions both in the number of cigarettes smoked and in the percentage of smokers. Their estimates are close to ours when 2003 is used as a proxy for 2004. We also show that other important determinants of BMI, beyond quitting smoking, did not vary significantly between 2003 and 2005. We use the Italian Household Budget Survey, provided by the Italian Institute of Statistics (ISTAT), to calculate the average real expenditure for food at home and outside it, which are considered as proxies for calorie intake. We estimate that real expenditure for food at home remains stable around a monthly average of 370 euro for the three years in question, whereas the expenditure for food outside the home moved from a monthly average of 56 euros in 2003, to 53 in 2004 and 54 in 2005. Consistently, physical exercise, which is a direct proxy for calorie expenditure, did not change over this period (ISTAT 2007). These results allow us to conclude that using information from 2003 as a proxy for that in 2004, cannot change our results significantly.

Figure 1 illustrates the BMI dynamic around the discontinuity[7]. We note that BMI rises significantly in the smoking ban year (2005), a dynamic which continues along its (positive) growth path. Instead, Figure 2 shows the average number of cigarettes smoked daily (panel a) and the average percentage of smokers per year (panel b). We find evidence of a clear deviation from the long-run paths of these variables corresponding to the year of the ban, 2005. The average number of cigarettes smoked fell from 14.5 to almost 13.5, whereas the percentage of smokers decreased by almost 2 percentage points. These findings indicate that the smoking ban played a significant role in reducing smoking, considering both cigarette consumption and the percentage of smokers.

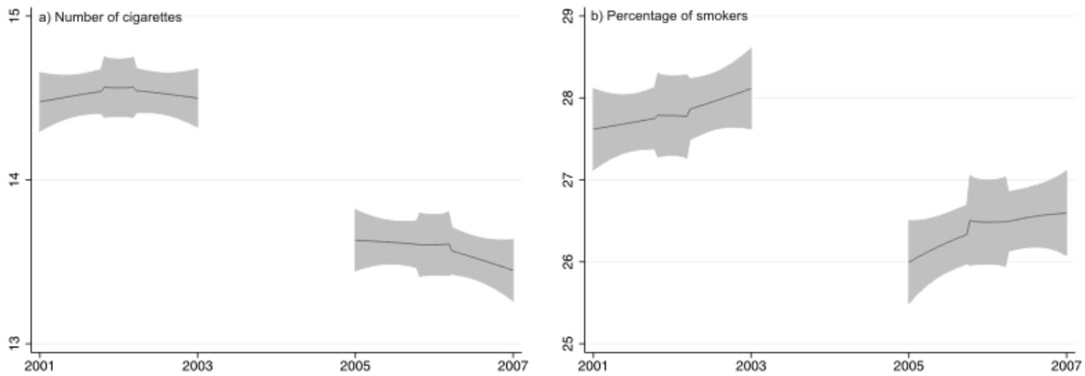
As we cannot be sure *a priori* that BMI variations, observed in Figure 1 around 2005, can be attributed solely to changes in smoking habits, we now analyse BMI variations for different groups of smokers descriptively. Our dataset allows us to distinguish between current, former and never smokers. Panel a) of Figure 3 shows the BMI patterns for the three groups, before and after the introduction of the smoking ban. We note that the only group which shows a significant increase in BMI after 2005 is composed of former smokers (moving from an average value of 25.03 before 2003 to 25.25 after 2005), whereas current and never smokers' BMI do not show significant increases in the post-ban period (moving from 24.25 and 23.95 in 2003 to 24.36 and 24.05 in 2005, respectively). The

[7]As calculated from ELA, BMI may determine measurement errors in estimations because it derives from self-reported weights and heights. However, this effect was not found to be large in adults after data adjustments (Zagorsky 2005, Burkhauser & Cawley 2008); in our sample, pregnant women's BMI was calculated according to weight before pregnancy.



Note: BMI values for each year were obtained by aggregating individual level data in pre- and post-reform periods. Solid line: estimated by standard Kernel function.

Figure 1: BMI discontinuity around clean indoor air law.



Note: Estimates for number of cigarettes and percentages of smokers are obtained as in Figure 1.

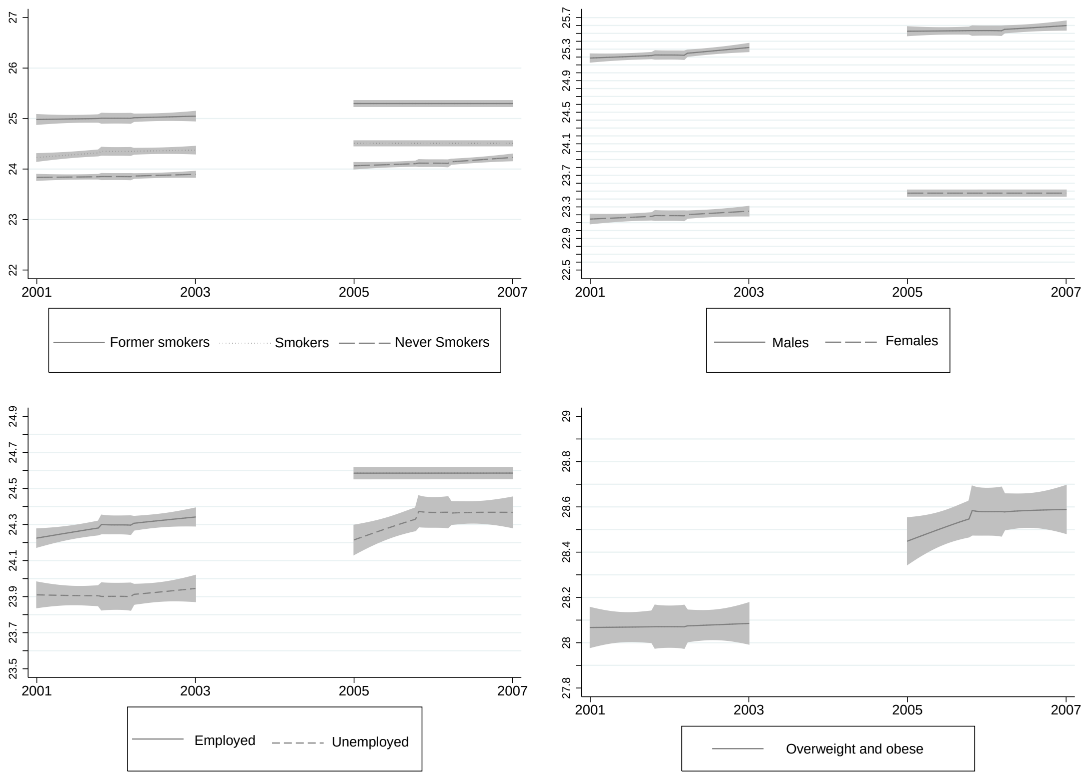
Figure 2: Smoking discontinuities around Italian clean indoor air law (2005). (a) Number of cigarettes; (b) Smoking participation rate.

average increase for the former smoker group is 0.22 points, and about 0.1 points for the other groups, meaning that former smokers increased their BMI twice as much as current or never smokers.

The findings discussed in Section 2 highlight the fact that smoking bans may have different effects on cigarette consumption when estimates are carried out by gender and occupational status. According to Table 1, men rather than women showed greater variations in terms of smoking reduction after the introduction of the ban and, as expected, employees rather than unemployed individuals showed larger variations in cigarette consumption. This result is in line with our expectations since in Italy the smoking ban was extended to workplaces common areas where employees, in particular men, are exposed for longer periods to smoking restrictions because of their higher occupation rate. Panels

b) and c) in Figure 3 compare different effects on BMI for these socio-economic groups: we note that men have the highest variations in terms of BMI, whereas employees show similar patterns to unemployed individuals, suggesting that the causal effects of smoking on BMI for these subgroups are not *a priori* predictable and, as described in the previous section, will also be investigated by estimating our models on these population subgroups.

Lastly, panel d) of Figure 3 shows BMI patterns for individuals at the top of the BMI distribution (i.e., overweight and obese), who represent a particularly interesting risk group for public health policy-makers. We find evidence of a significant rise in BMI between 2003 and 2005, also associated with a substantial decrease in cigarette consumption (see also Table 1).



Note: Estimates for BMI patterns of subsamples obtained as in Figure 1

Figure 3: BMI discontinuities around clean indoor air law, by subgroup.

4 Results

Before presenting the estimates of the causal effects of smoking habit changes on BMI, we list in Table 2 the estimates of least squares regression, evaluating the simple correlation

Table 1: Definition of variables and descriptive statistics.

	Category		Percentage of smokers				Cigarette consumption (no.)			
			IV sample		IV-RD sample		IV sample		IV-RD sample	
		%	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
Strenuousness of	Low	0.31	0.31	0.29	0.32	0.3	15.3	14.02	14.85	14.06
work at home	Moderate or high	0.69	0.25	0.23	0.25	0.22	13.47	12.57	13.13	12.53
Job 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 of										
at-risk health groups										
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

Note: Percentage of cases and average variables in pre- and post-reform periods, for IV sample (2001-2003 and 2005-2007) and IV-RD sample (2003-2005), in each variable used to estimate causal relationship between smoking and body weight.

among the variables of interest (equation (1)). Although the parameters estimated from this equation have the expected sign and are significant at the conventional 1% level, they are also very small in magnitude, suggesting that endogeneity plays an important role in biasing the parameters estimated from this specification.

Table 3 lists the coefficients estimated from the reduced and structural form models (equations $2-4$) separately for the IV (columns 1-5) and IV-RD (columns 6-10) samples. The models in Table 3 account for differences in observable and unobservable charac-

Table 2: OLS estimates of effect of smoking on BMI.

Variables	**Adults born in 1941 - 1989,** whole sample (2001-2007)	**Adults born in 1941 - 1989,** discontinuity sample (2003-2005)
Number of cigarettes	-0.010***	-0.016***
	(0.001)	(0.001)
Percentage of smokers	-0.002***	-0.004***
	(0.000)	(0.001)

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

teristics, including the covariates listed in Table 1 and time trends, cohorts, age and regional specificity and dynamics, respectively. Column (1) shows a positive correlation between the implementation of the CIAL and BMI, with an estimated increase of 0.17 points [s.e.=0.043]. As expected, the ban is also significantly correlated with reductions in cigarette consumption [(δ_1=-0.40; s.e.= 0.093)] and percentages of smokers [(δ_1=-2.25; s.e.= 0.560)]. Causal estimates (column 3) indicate the negative effect of cigarette consumption on BMI [θ_1=-0.42; s.e.=0.144], meaning that a decrease in smoking is associated with an increase in terms of BMI. Column 5 shows that the BMI variation induced by a decrease in the percentage of smokers (i.e., quitting smoking) is substantially responsible for the entire smoking-related BMI variation (θ_1=-0.08, s.e.=0.026), whereas the effect of smoking reductions, measured indirectly through cigarette consumption, only makes small contribution. This result can be seen by comparing the BMI changes estimated from the two indicators, once we rescale the estimated parameters for the percentage of smokers in the population (see, for a discussion, Baker et al. (2008) and Havnes & Mogstad (2010)). In our example, the estimated effect on increased BMI attributable to quitting smoking is -0.30 (i.e., $-0.08/0.27$), where 0.27 at the denominator is the percentage of smokers in the population.

Looking at the estimates carried out on the IV-RD sample, we find a similar effect of smoking on BMI changes. The magnitude of the BMI variation, shown in column (8), is not statistically different from that estimated from the IV sample ($\theta_1 = -0.38$; s.e= 0.077): again we find confirmation that the estimated causal effect on BMI (column 10), is mainly due to changes in the percentage of smokers ($\theta_1 = -0.09$; s.e. = 0.021). This result, as already illustrated above, is obtained by dividing the parameter measuring the causal BMI variation associated with the percentage of smokers by the share of smokers in the Italian population, to make it comparable with that estimated by the number of cigarettes smoked [i.e., $-0.33 = 0.09/0.27$].

This strategy cannot exclude the possibility that the proposed estimates are still affected by unobserved time-varying confounders. Here, we use the IDW estimator, which assigns higher weights to those observations closer to the year of the ban, to verify the estimates carried out on the IV sample (Table 3). The estimated parameters of equations $2-4$, obtained from the IDW estimator (Table 4), are quantitatively the same as those shown in Table 3. This provides further support for the robustness of our identification strategy on the effect of unobserved variables.

According to economic literature findings, discussed in section 2, we now evaluate the dimension of heterogeneous BMI responses to smoking habit changes in specific subgroups of interest. In particular, the extension to workplace common areas of the anti-smoking policy in Italy, also determines a greater exposure of employee smokers, increasing the probability of affecting the smoking habits of this group of the population.

Reduced-form estimates for employees' BMI and smoking habits are listed in columns (1-2-4) (IV sample) and (6-7-9) (IV-RD sample) of Table 5. Looking at the smoking equations, we note how the smoking ban significantly affected employees' smoking habits. More interestingly, and unlike the findings of studies in North European countries (see, Schunck & Rogge (2010)), the effect for this group is larger than that obtained from baseline estimates, for each smoking indicator adopted and irrespective of the sample used. However, the estimated BMI variation due to the smoking ban for the employee group (column (1)) is close to that obtained from baseline estimates. Consequently, in structural equation (4) we find a smaller BMI increase, due to smoking reductions, with estimated parameters of 0.33 (s.e.= 0.158) and 0.32 (s.e.= 0.129) for IV and IV-RD samples, respectively. The magnitude of the effect is found to be very similar when we consider the percentage of smokers as a proxy for smoking habits.

Tables 6 and 7 estimate the effect of smoking habit changes in men and women. We find evidence that the smoking ban had larger significant effects on men's smoking habits, because, as already noted, male smokers are more likely than women to be exposed to the restrictions imposed by the ban, because of higher employment rates and the larger amount of time spent at pubs, cafés and restaurants at lunchtime. Interestingly, although we find a higher correlation between the smoking ban and BMI for men ($\beta_1 = 0.20$) compared with women ($\beta_1 = 0.14$), the ratio between correlation parameters, estimated from equations (2) and (3), give rise to a lower causal estimate of the effect of smoking habits on BMI in men. For example, using the RD sample, we have BMI variations of 0.34 for men and 0.47 for women, respectively.

As an analysis of sensitivity, we now carry out IDW estimates for working status and gender. The results are shown in Appendixes A.1-A.3. Comparing the IDW estimates of these subgroups with those obtained with the IV or IV-RD samples, we observe that the coefficients are close to each other.

Table 3: 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 (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	0.17***	-0.40***		-2.25***		0.17***	-0.46***		-1.94***	
	(0.043)	(0.093)		(0.560)		(0.028)	(0.060)		(0.361)	
Number of cigarettes			-0.42***					-0.38***		
			(0.144)					(0.077)		
Percentage of smokers					-0.08***					-0.09***
					(0.026)					(0.021)
Constant	19.58***	0.33	19.72***	30.23	21.82***	18.30***	-1.04	17.91***	20.14*	20.11***
	(2.397)	(4.012)	(2.763)	(34.986)	(3.193)	(0.811)	(1.667)	(1.007)	(10.607)	(1.255)
Observations	170,702	170,702	170,702	170,702	170,702	57,409	57,409	57,409	57,409	57,409
R-squared	0.22	0.06		0.04		0.21	0.06		0.04	
Adj. R-squared	0.21	0.06	.	0.04	.	0.21	0.05	.	0.03	.

Notes: Column (1) lists reduced-form estimates in equation (2) of the effect of smoking ban in January 2005 on BMI. Columns (2) and (4) also list of reduced-form estimates 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: p-value *** $\leq$ 0.01, ** $\leq$ 0.05, * $\leq$ 0.1.*

Table 4: Causal effect of smoking on BMI - IDW estimates.

	Adults born between 1941-1989, years 2001 - 2007				
		Number of cigarettes		**Percentage of smokers**	
	BMI	Smoking	BMI	Smoking	BMI
	(reduced form)	(reduced form)	(structural form)	(reduced form)	(structural form)
	(1)	(2)	(3)	(4)	(5)
Smoking Ban	0.15***	-0.44***		-2.50***	
	(0.044)	(0.095)		(0.566)	
Number of cigarettes			-0.37***		
			(0.123)		
Percentage of smokers					-0.07***
					(0.022)
Constant	19.60***	0.46	19.76***	29.53	21.41***
	(2.469)	(4.043)	(2.780)	(35.519)	(3.062)
Observations	170,702	170,702	170,702	170,702	170,702
R-squared	0.21	0.06		0.04	
Adj. R-squared	0.21	0.06	.	0.03	.

*Notes: Column (1) lists reduced-form estimates in equation (2) of the effect of smoking ban in January 2005 on BMI. Columns (2) and (4) also list of reduced-form estimates 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). All estimates include covariates described in Table 1 as controls . Standard errors in round brackets. Significant levels: p-value *** $\leq$ 0.01, ** $\leq$ 0.05, * $\leq$ 0.1.*

Table 5: 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	0.14***	-0.41***		-2.27***		0.17***	-0.53***		-1.98***	
	(0.050)	(0.124)		(0.713)		(0.034)	(0.083)		(0.500)	
Number of cigarettes			-0.33**					-0.32***		
			(0.158)					(0.075)		
Percentage of smokers					-0.06**					-0.08***
					(0.028)					(0.022)
Constant	16.38***	-6.21	14.31***	-4.94	16.08***	19.53***	1.36	19.85***	43.77***	22.72***
	(4.419)	(8.695)	(4.524)	(67.425)	(4.105)	(1.032)	(2.564)	(1.376)	(15.639)	(1.878)
Observations	110,559	110,559	110,559	110,559	110,559	37,280	37,280	37,280	37,280	37,280
R-squared	0.23	0.05		0.03		0.23	0.05		0.03	
Adj. R-squared	0.23	0.05	.	0.03	.	0.23	0.05	.	0.03	.

Notes: Column (1) lists reduced-form estimates in equation (2) of the effect of smoking ban in January 2005 on BMI. Columns (2) and (4) also list of reduced-form estimates 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: p-value *** ≤ 0.01, ** ≤ 0.05, * ≤ 0.1.*

Table 6: 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	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	0.20***	-0.50***		-2.48***		0.21***	-0.66***		-2.37***	
	(0.054)	(0.155)		(0.834)		(0.036)	(0.098)		(0.535)	
Number of cigarettes			-0.39**					-0.32***		
			(0.163)					(0.075)		
Percentage of smokers					-0.08**					-0.09***
					(0.034)					(0.026)
Constant	18.30***	-3.41	16.96***	17.90	19.73***	18.75***	-3.58	17.59***	21.08	20.64***
	(3.472)	(5.459)	(3.755)	(45.604)	(4.284)	(1.075)	(2.703)	(1.399)	(15.650)	(1.871)
Observations	84,164	84,164	84,164	84,164	84,164	28,327	28,327	28,327	28,327	28,327
R-squared	0.13	0.04		0.03		0.13	0.04		0.03	
Adj. R-squared	0.13	0.04	.	0.03	.	0.13	0.03	.	0.03	.

Notes: Column (1) lists reduced-form estimates in equation (2)), i.e., effect of smoking ban in January 2005 on BMI. Columns (2) and (4) also list of reduced-form estimates 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: p-value *** $\leq$ 0.01, ** $\leq$ 0.05, * $\leq$ 0.1.*

Table 7: 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 (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	0.14**	-0.33***		-2.21***		0.13***	-0.28***		-1.58***	
	(0.066)	(0.102)		(0.730)		(0.043)	(0.067)		(0.483)	
Number of cigarettes			-0.42*					-0.47***		
			(0.228)					(0.179)		
Percentage of smokers					-0.06*					-0.08**
					(0.035)					(0.035)
Constant	18.91***	-0.03	18.90***	27.96	20.65***	16.14***	-1.14	15.60***	7.71	16.79***
	(2.928)	(3.975)	(3.294)	(40.067)	(3.700)	(1.217)	(1.904)	(1.454)	(14.333)	(1.710)
Observations	86,538	86,538	86,538	86,538	86,538	29,082	29,082	29,082	29,082	29,082
R-squared	0.18	0.02		0.02		0.17	0.02		0.02	
Adj. R-squared	0.17	0.02	.	0.01	.	0.17	0.01	.	0.01	.

Notes: Column (1) lists reduced-form estimates in equation (2) of the effect of smoking ban in January 2005 on BMI. Columns (2) and (4) also list of reduced-form estimates 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: p-value *** $\leq$ 0.01, ** $\leq$ 0.05, * $\leq$ 0.1.*

4.1 Conditional BMI estimation: effects for overweight and obese people

One limitation of the previous estimates is that smoking habit effects are only estimated at the average of BMI distribution. However, policy-makers are interested in knowing the effect of weight changes in at-risk sub-groups of the population like obese and overweight people. Here, we estimate the effects of smoking habits on specific quantiles of the BMI distribution corresponding to the mean of overweight individuals (OV), in our sample at the 77^{st} percentile and overweight and obese individuals (OVOB) at the 81^{st} percentile. We base this choice on evidence that being overweight is a more important problem than obesity in Italy (Pieroni et al. 2011).

To carry out these estimates, we use an instrumental variable quantile regression (IVQR) estimator, (Chernozhukov & Hansen 2008), which exploits the potential outcome framework under LATE identification assumptions. We list the estimated coefficient from this model in Table 8, for the IV-RD sample only. Quantile regression parameters have negative sign and are statistically different from zero, like those obtained from the IV-RD sample.

To help interpretation of the magnitude of these effects, let us consider that the difference between OW and baseline estimates is -0.09 (i.e.,$\Delta BMI_{IV-RD} = -0.38$, as against $\Delta BMI_{OW} = -0.29$). Our estimates also indicate that including obese individuals mitigate the adverse effects of smoking habits on BMI. Estimates at the 81^{th} percentile (i.e., OBOW group) indicate a further reduction of the causal effect of smoking on BMI; this coefficient is about 34% smaller than that estimated at the sample mean (from $\Delta BMI_{RD} = -0.38$ to $\Delta BMI_{OBOW} = -0.25$, respectively). Although fewer observations in the upper tail of our sample do not allow us to obtain estimates for higher quantiles of the BMI distribution, estimates made at the quantiles corresponding to the average of the OW and OBOW groups are in line with our main findings. Significant although small effects of smoking changes on BMI, match the results of Fang et al. (2009) for China and Flegal (2007) for the United States[8].

This result is explained by the fact that, when at-risk weight people reduce smoking, and especially when they quit, they may also change other life-styles toward better health. Let us consider as an example changes in alcohol consumption. Drinking has

[8]The complete quantile IV estimates around the mean of overweight and overweight and obese groups (from 75^{th} to 83^{th} percentile of BMI distribution) are available upon request from the authors.

also been shown to be a complement of smoking and is considered to be an indicator of personal addictive traits (Arcidiacono et al. 2007). In addition, previous literature has found that alcohol consumption may lead to higher body weight (Colditz et al. 1991, Lukasiewicz et al. 2005, Arfi & Rohrer 2005). Thus, smoking reduction in obese people - who are known to have more severe health problems and greater concerns about their health - should also lead to larger reductions in alcohol consumption and explain the small increase in BMI with respect to the effect estimated at the mean of the BMI distribution.

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

	Number of cigarettes	**Percentage of smokers**
Variables	**77^{th} (Overweight)**	**81^{st} (Overweight and Obese)**
Nicotine consumption	-0.29***	-0.25***
	(0.045)	(0.039)
Percentage of smokers	-0.05***	-0.06***
	(0.012)	(0.019)

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

We now turn to a more policy-oriented analysis of the effects of smoking reductions on weight gain. Using the IV-RD sample, we estimate the percentage BMI variation resulting from a 1% variation in the number of cigarettes or in the percentage of smokers (Table 10). Elasticities are calculated in order to make the magnitude of the smoking indicators easier to interpret and make them comaprable across categories of individuals with different BMI. The results do show that BMI responses due to smoking reductions are mostly attributable to quitters, irrespective of the sample used. 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, whereas people at-risk of overweight have a lower estimated elasticity than that obtained in the baseline model.

4.2 Body weight estimates to changes in smoking habits of smokers

Most of the estimated BMI effects due to changes in smoking habits, although statistically significant at conventional levels, are quite small. On one hand, this result is reassuring for policy-makers worried by the fact that obesity-related health costs will not increase too

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

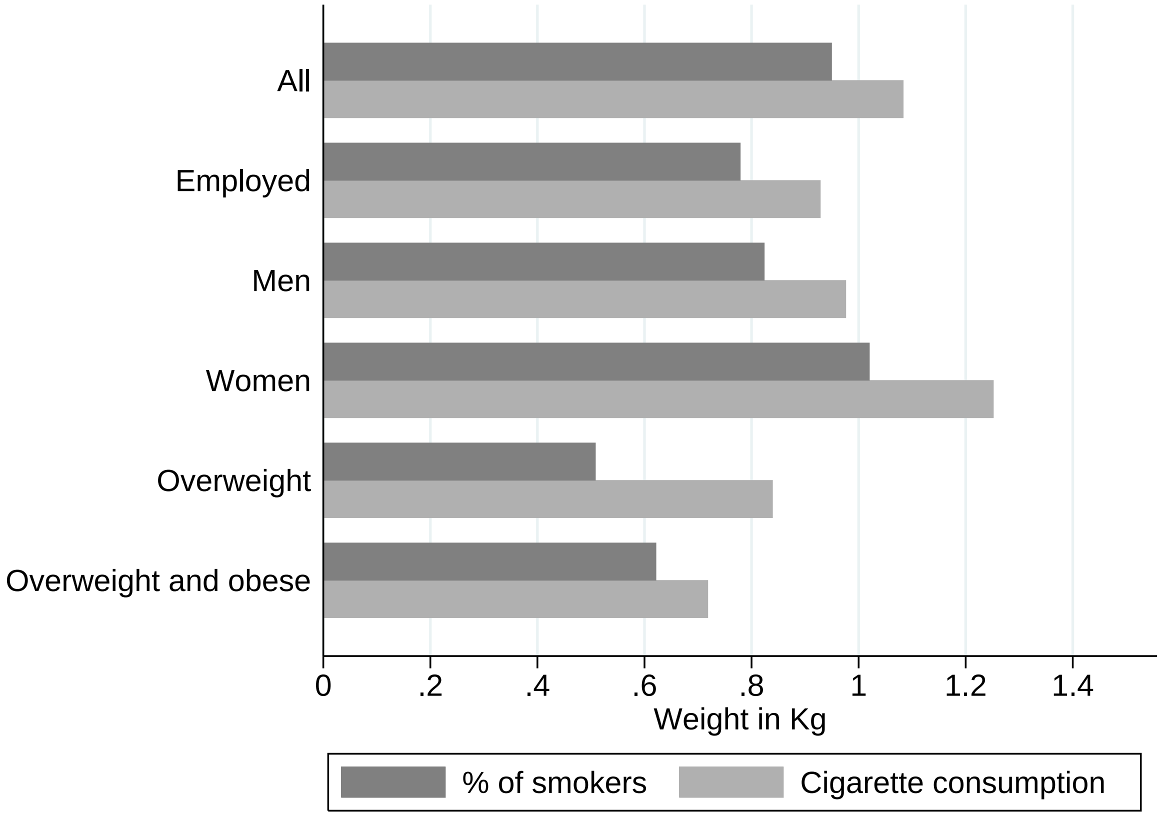
Sample	**Number of cigarettes**	**Percentage of smokers**
All subjects	-0.07***	-0.08***
	(0.023)	(0.029)
Employed	-0.06***	-0.07***
	(0.028)	(0.034)
Men	-0.08***	-0.11***
	(0.034)	(0.046)
Women	-0.04*	-0.06*
	(0.024)	(0.031)
Overweight	-0.04***	-0.05***
	(0.006)	(0.004)
Overweight and Obese	-0.035***	-0.06***
	(0.004)	(0.005)

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

much with respect to the benefits derived from reducing smoking; on the other hand, we have added new evidence about the causal effect of smoking on body weight to the findings of the existing literature on this topic. Figure 5 shows the variations in terms of weight, estimated from the IVRD sample for the entire population and the other selected groups already described. We translate the effects on BMI in terms of weight, by multiplying each estimated coefficient by the average squared height of each sample analysed. Figure 5 shows that a unitary reduction in cigarette consumption causes a rise in body weight of 1.1 kg. We also estimate that more than 90% of this variation depends on the effect of quitters, implying that the increase in weight accounts for more than 0.9 kg.

From the estimated parameters, employed individuals' and men's weight gains are slightly lower than those of the entire population. However, irrespective of the smoking indicator used, the differences in terms of weight among samples are limited in all cases. For example, with number of cigarettes as an indicator of smoking, women's weight gains are 1.3 kg, whereas men have a variation of 0.9 kg for a unitary cigarette reduction. Note that the weight variation for employed individuals (0.95 kg) is very close to that estimated from the baseline model.

In addition, although smoking reductions may theoretically be undesirable if they



Notes: Light bars: weight changes of cigarette consumption; dark bars: effect of quitters only. Effect on weight of cigarette consumption and percentage of smokers retrieved by multiplying coefficients obtained from IV-RD sample (columns (8) and (10) of Tables 3-7) 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 4: Causal effect of smoking on weight. Discontinuity sample.

increase obesity too much, our estimates of the effect on overweight (and obesity) are reassuring for Italy. The limited effect on weight changes for individuals in these ‘’weight risk” groups leads to the prediction that future policies implementing cuts in smoking should keep down the health costs related to obesity.

5 Robustness analysis

In this section we analyse the robustness of our results to the inclusion of region-specific trends interacted with cohort dummies and age and to the location of the threshold dividing pre- and post-reform observations. Lastly, we also test whether BMI variations before and after the smoking ban are attributable to groups of individuals whose smoking behaviors were affected by the reform.

Generally, estimates of the relationship between smoking and BMI according to the usual IV or IDW estimators tend to be stable when we control for regional time trends and other time-varying regressors. This suggests that the variables already included in equation (4) do control for unobserved regional trends. However, as in Lochner & Moretti (2004), we conduct here a robustness of our estimates to different specifications. The results of this analysis are listed in Table 10. Specification *a*) reports the base case results from Table 3 (columns 3 and 5) for ease of comparison. The following three models aim at absorbing trends, which are specific to the region of residence to account for geographic differences in BMI over time, as well as differences in other time-varying factors which are specific to the region of residence and correlated with weight changes. Specification *b*) includes the interaction between region of residence and linear trends in year of birth. Specification *c*) includes the interaction of effects of region of residence and cohort of birth. Lastly, specification *d*) allows the cohort effects to vary with age, capturing the possibility that age-related smoking patterns vary over time. Overall, the estimates of the various specifications are similar to the base case. Our findings indicate that other unobserved time-varying factors are not likely to be empirically important after controlling for age, time, region of residence, and birth cohort.

Table 10: Causal effect of smoking on body weight - robustness checks.

	Number of cigarettes	**Percentage of smokers**
Base case	-0.42***	-0.07***
	(0.144)	(0.026)
Region of residence × cohort trend	-0.42***	-0.08***
	(0.128)	(0.021)
Region × Cohort effects	-0.42***	-0.08***
	(0.118)	(0.019)
Age × Cohort effects	-0.42***	-0.08***
	(0.139)	(0.023)

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

Here, we also conduct a placebo test for the location of the discontinuity at various cut-off years. Although the Italian smoking ban came into force in January 2005, choosing another year as the date of its introduction, may lead to estimates of larger smoking reductions or BMI increases, casting doubt on the effectiveness of the identification strategy based on the smoking ban. If we do not find that the estimated reduction in cigarette consumption is highest when the threshold is set at the true date of introduction of the ban, other unobservable variables may be affecting smoking or BMI patterns. Figure 5 (panels a-c) shows the estimated parameters obtained from the reduced-form models for smoking and BMI (equations 2-3) by varying the date of introduction of the ban in the period 2001-2007. We find that, consistently with our expectations, the only significant change in the key variables of our model appears exactly in 2005, the year when the smoking ban was introduced.

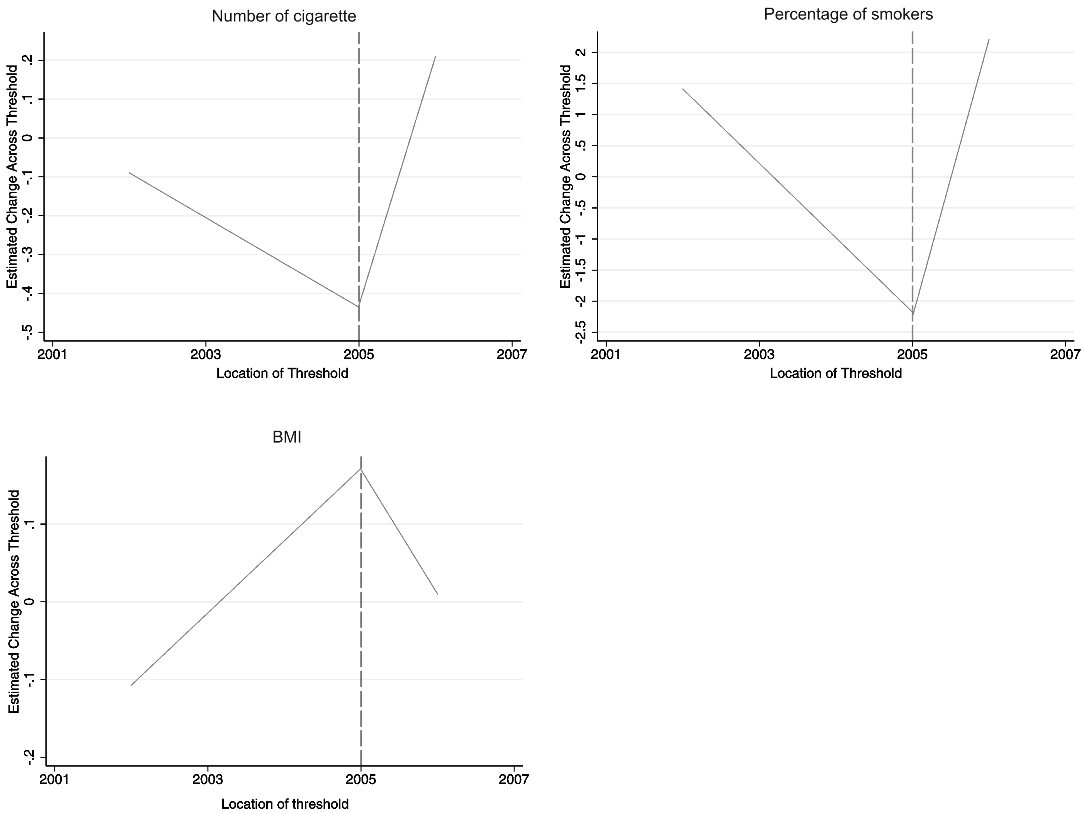


Figure 5: Location test for the key variables of the models

In addition, we compare our results with those obtained from a DID approach, with the aim to confirm that post-ban BMI variations are due to changes in smoking habits. In particular, we test whether BMI variations in a treatment group of individuals, which would in principle be affected by the smoking ban, are larger than those of a control group, which should be unaffected by the ban. We use former and current smokers as treatment groups and non-smoker individuals as a natural control group.

Table 11: Smoking ban effect on BMI - Robustness checks by smoking status.

	Difference-in-Differences	**Coefficients**
a)	Smoke ban	0.13**
		(0.051)
	Smoke ban*Former smokers (CG: never smoker)	0.08*
		(0.044)
b)	Smoke ban	0.12**
		(0.053)
	Smoke ban*Current smokers (CG: never smokers)	-.034
		(0.039)

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

The DID estimates in Table 11 indicate an important and statistically significant effect on BMI, identified entirely from former smokers[9]. As expected, when we compare BMI variations in former and never smokers (panel a), the dimension of the estimated DID parameter (i.e., 0.08) matches the one listed in column (5) of Table 3, using the percentage of smokers. Instead, when we compare BMI variations in current smokers with those in never smokers, aimed at evaluating the importance of reductions in cigarette consumption, the estimates (panel b) do not evidence a significant difference between groups.

6 Conclusions

A long-standing prediction in health economics is that body weight gains may be partly explained by reduced cigarette consumption. In practice, this trade-off is highly dependent on smokers' responses, 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. Some papers have also recently questioned the significance of this relationship, based on the evidence that smoking reduction is often linked with unobserved individual health status and forward-looking individual behavior, which in turn, may make causal estimates of smoking on body weight move upward or downward. More importantly, these correlation biases may variously affect socio-economic groups or groups of interest for public health, i.e., overweight and obese.

[9]This specification is similar to equation (3), reported in Liu et al. (2010).

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 generated such a variation and this was the background for our research design. With this law, individuals of the same age, but born in adjacent birth cohorts, face different degrees of smoking restrictions in public places.

Using this evaluating approach, we find that smokers significantly respond to the smoking ban, causing sudden negative changes in cigarette consumption. We attempt to estimate the magnitude of smoking habit changes on weight with a simplified structural model. We require the data to be accommodated to estimate this effect over a ex-post period of three years (2005-2007) by an IV-RD sample, which we compare with an IV sample to assess smoking reduction on BMI in a post-period year. Irrespective of the sample and estimator used, these models predict positive, although small, BMI changes to reduction in smoking habits. A caveat to this general conclusion may involve specific estimates for employed individuals and gender differences. However, although the exogenous shock of the smoking ban on men and employees has adverse effects on smoking habit indicators, such as percentage of smokers and cigarette consumption, weight gains are reduced and close to models that use the whole sample.

We conclude that decreasing smoking participation rates or cigarette consumption has limited effects on weight gains, which are even smaller in overweight and overweight and obese people. With respect to the literature, we favor a less restrictive explanation of these findings: that a decreasing causal effect of smoking reductions causes a correspondingly 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 to the near future.

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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 an	0.13**	-0.44***		-2.45***	
	(0.051)	(0.126)		(0.720)	
Number of cigarettes			-0.29**		
			(0.141)		
Percentage of smokers					-0.05**
					(0.025)
Constant	16.55***	-4.69	15.20***	-2.26	16.44***
	(4.535)	(8.396)	(4.488)	(69.590)	(4.192)
Observations	110,559	110,559	110,559	110,559	110,559
R-squared	0.22	0.05		0.03	
Adj. R-squared	0.22	0.05	.	0.03	.

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	0.19***	-0.56***		-2.73***	
	(0.055)	(0.156)		(0.844)	
Number of cigarettes			-0.35**		
			(0.140)		
Percentage of smokers					-0.07**
					(0.030)
Constant	17.68***	-4.17	16.23***	12.15	18.54***
	(3.512)	(5.635)	(3.754)	(47.567)	(4.123)
Observations	84,164	84,164	84,164	84,164	84,164
R-squared	0.13	0.04		0.03	
Adj. R-squared	0.13	0.04	.	0.03	.

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	0.11*	-0.35***		-2.43***	
	(0.067)	(0.105)		(0.746)	
Number of cigarettes			-0.32*		
			(0.170)		
Percentage of smokers					-0.05*
					(0.027)
Constant	19.50***	0.81	19.76***	30.38	20.90***
	(3.067)	(3.980)	(3.336)	(40.292)	(3.584)
Observations	86,538	86,538	86,538	86,538	86,538
R-squared	0.17	0.02		0.01	
Adj. R-squared	0.17	0.01	.	0.01	.

Notes: See Table 6.