De-normalizing smoking in urban areas: Public smoking bans and smoking prevalence

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Abstract

This paper investigates the effect of public smoking bans on smoking prevalence in bars and restaurants in Bogotá, Colombia. In 2010, Colombia introduced a business-supported smoking ban in bars and restaurants and all public indoor spaces. In this paper, we use the matching-difference-in-differences technique in analyzing household consumption data from the 2007 and 2011 quality of life surveys, to explore how households respond to the cultural norm change. This is done by exploiting their geographical proximity to dense commercial areas. We found that after the implementation of the smoking ban, smoking prevalence reduced in households near high-density commercial blocks compared to households near low-density commercial blocks. We conclude that since households near high-density commercial blocks are more frequently exposed to smoking than households near low-density commercial blocks, the latter would be more willing to internalize the smoking de-normalization process. Therefore, they will be most exposed to compliance with the law and individuals within such areas will have a reduced probability of becoming smokers.

Keywords: Public smoking bans; smoke-free laws; cigarette consumption; temptation goods; density; proximity

JEL Classification: C31; I12; I18; R28

Declarations of interest: none

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1 Introduction

Noncommunicable diseases related to tobacco consumption kill more than 8 million people every year (WHO, 2017). Governments worldwide tackle these public health threats with a set of tobacco control policies aimed at reducing smoking prevalence and its health consequences (Organization et al., 2004). Tobacco control policies are among the current strategies in emerging economies, but their effects on smoking habits and health outcomes are less known. Policies range from excise taxes to public smoking (smoke-free environments) and advertising bans, which discourage take-up habits, promote smoking cessation, and enhance healthy habits (Chaloupka and Grossman, 1996; Farrelly et al., 2001; Douglas, 1998). These sort of command-and-control policies related to tobacco use have been studied in high-income countries (Gruer et al., 2012; Lewit et al., 1981; Czart et al., 2001), but there is limited evidence on their effects in low and middle-income countries (Gruer et al., 2012; Sebrié et al., 2008). Understanding policies aimed at the low income countries is essential as there is a threat that additional income results in an increase in 'temptation goods' consumption (Banerjee and Mullainathan, 2010; White and Basu, 2016; Evans and Popova, 2017).

Apart from direct health externalities related to second-hand smoking, smoking bans might have direct impacts on smoking behavior (Adda and Cornaglia, 2010; Bharadwaj et al., 2014, 2010). While evidence of the reduction of the intensity of smoking prevalence on the general population is not clear (Jones et al., 2015; Goodman et al., 2009), smoking bans can reduce the prevalence of smoking of those individuals who are typical users in places where the ban is implemented (Anger et al., 2011; Borland et al., 2006; Shopland et al., 2001; Evans et al., 1999; Chapman et al., 1999). These expositional differential effects are well known in literature and the spatial dimension plays an important role. Density around and proximity to tobacco outlets are known to be associated with the intensity of teenagers' smoking and the reduced odds of smoking cessation. There have even been proposals to limit retailer density in urban areas (Finan et al., 2019; Luke et al., 2017; Pearson et al., 2015; Halonen et al., 2014). While the standard argument is associated with traveling costs, an alternative approximation is based on social norms and the social cognitive theory. Under this idea, an individual's ability to maintain habit changes depends on the practices of the social system (Bandura, 1998).

In this article, we explore the role of geographic exposure to the introduction of smoking bans in public indoor spaces, such as bars and restaurants. We study the effect of the tobacco control policy on the smoking behavior of the population of Bogotá. We intend to shed light on the effects of a non-pecuniary policy intervention on smoking, providing evidence of the policy's impact on the extensive margin, by analyzing the possible mechanisms through which households might change their smoking behavior.

We use household-level data from the quality of life surveys *Encuesta de Calidad de Vida de Bogotá* 2007 (ECVB-2007) and its paired survey: the *Encuestra Multipropósito de Bogotá 2011* (EMB-2011). These cross-sectional surveys contain information on household expenditures on different categories, including tobacco expenditure, which is used as an indirect measure of household smoking prevalence. As these surveys are designed to obtain representative statistics at the city's geographic units, the spatial coverage of the census blocks used for the study helped us in performing a spatial analysis. First, we computed commercial geographical areas based on a census of restaurants, bars, cafes, and nightlife. Second, we utilized a matching technique to balance the households near blocks with commercial activity against households located far from commercial blocks. Third, a difference-in-differences (DiD) strategy was employed to measure the ordinance's effect on household smoking behavior. The DiD strategy examines the implementation of the smoking ban as an exogenous source of variation to understand the dynamics of household smoking prevalence, using distance to commercial establishments as the dimension of spatial exposure to tobacco use. The intensity in which a household is exposed to commercial activity could deepen the effects of the policy. Hence, commercial density is used to explore heterogeneous effects by intensity. Results are compared to alternative definitions of proximity and density.

If the policy is effective, there would be reductions in smoking prevalence. People close to commercial spots would be less spatially exposed to tobacco use and would experience lower advertising exposure. This reduction could happen due to lower take-up habits, the learning of the de-normalization of smoking, and the increase in the probability of compliance with the norm. Moreover, being exposed in greater intensity (higher commercial density) can reduce the prevalence to a greater extent, since the commercial activity within the household's vicinity is more significant and the law is often enforced. The findings suggest that being near commercial activity does not significantly affect household smoking behavior (prevalence) due to the implementation of the law. However, the policy's effect on prevalence comes from commercial density to which a household is exposed. Following the implementation of the law, we estimate a 9.6 percentage point decrease in smoking prevalence for households that are close to high-density

commercial blocks, compared to households near low-density commercial blocks. Consequently, as the law reduces tobacco usage around commercial establishments, the effect is that less spatial and social exposure to cigarette use discourages take-up of smoking and the permanence of the habit.

Furthermore, it is of great importance to understand the effect of the policy at an aggregate level when one considers that parents, peers, and siblings act as role models, influencing attitudes toward smoking (Meier, 1991; Otten et al., 2007; Wilkinson et al., 2008). It is also pertinent to note that the availability of purchase within a household has a positive impact on initiation (Lewit et al., 1981). This research measures the effect of tobacco consumption exposure on household smoking prevalence, taking into account the decision making within the household as may be affected by each member of the household. This study uses data on household smoking prevalence, as information on household members' smoking habits could not be obtained.

An in-depth analysis of how people internalize the de-normalization of smoking will also be undertaken. It has been shown in other contexts (Krupka and Weber, 2009, 2013; Bicchieri and Chavez, 2010), that social norms play a fundamental role in the internalization of socially desired behaviors. The literature presents several mechanisms through which social norms affect social behavior. Two of them correspond to focusing and informational effects of norms on individuals' actions; they consider adaptative conduct under prescriptions of appropriate actions and imitation behavior (Krupka and Weber, 2009).[1]

We also analyze three socio-demographic results that the literature has presented. The literature has shown that a longer smoking duration makes the cessation processes more difficult, as it becomes an addictive behavior (Douglas and Hariharan, 1994; Becker and Murphy, 1988). Second, we explore the presence of children as it has also been shown that household composition is crucial in tobacco consumption decisions. Parents consider their children's wellbeing when deciding to smoke as children learn healthy or harmful behaviors from their parents. Third, the literature has also shown that higher socioeconomic status leads to lower tobacco consumption (Farrelly et al., 2001; Chaloupka et al., 2011). In this sense, this research consider impacts separately for skilled and unskilled household heads.

Section 2 of this research presents the context within which the law was settled, describes the data, and shows the empirical strategy that will be used to understand the effect of the law. Section 3 presents the results of the heterogeneous effects on exposure intensity and socio-demographic characteristics. Section 5 discusses the results and concludes.

2 Methods

3 Context

Following the WHO Framework Convention on Tobacco Control, Colombia undertook several policies to curb tobacco consumption favoring public health during the first two decades of the 21st century. Price and non-price related policies have been placed on the government's agenda. On the one hand, a non-price-related policy (Law 1335) was issued by Congress in July 2009 and entered into force immediately. It had a smoke-free environment orientation. One of its main components was "*Espacios Libres de Humo*", an initiative to curb tobacco use through the prohibition of tobacco consumption in indoor public places.

A recent study by Uang et al. (2018) on the implementation of smoke-free environments in Colombia shows that the oversight of non-governmental organizations, external funding, and support from the hospitality/tourism industry contributed to effective implementation of the policy. In terms of law enforcement, Bogotá was one of the cities that implemented monitoring plans in sanitary inspections and 91% of commercial establishments complied with the law. There is also evidence of self-enforcement in the hospitality industry. Evidence from other countries shows that recent enforcement of anti-smoking legislation improves public health without a corresponding negative impact on the economic outcomes in the hospitality industry (Pieroni and Salmasi, 2017).

[1] Online Appendix A describes in detail the potential transmission mechanisms. We cannot explore them in detail in this research due to data restrictions.

4 Data

This research uses information on household expenditure, socio-demographic characteristics of household heads, and commercial spots in Bogotá. The unit of analysis is the household and variation occur at the block level. Treatment "intention" is assigned using households' exposure to commerce activity since the law directly affects the advertising, promotion and cigarette consumption in public areas to which a household would be exposed. Two measures of exposition are considered:

Distance: The distance in meters from the household block to the nearest commercial (a block with at least one commercial establishment).

Intensity: For the closest commercial block, the number of commerce spots in such block over the area of the block in kilometres.

The central assumption is that the distance and the density of the commercial activity that surrounds a household might influence the decision to smoke, i.e., being close and with greater density of commerce makes a household more exposed to tobacco use, and therefore influence its members smoking decisions. This behavioural assumption is behind the idea of the policy.

This section will present the construction of the measures described above, and the possible issues that could affect our identification strategy later on.

2.2.1 Commercial establishments

The data on commercial establishments is obtained from the *Departamento Administrativo Nacional de Estadística* (DANE) - *Directorio Nacional de Empresas*, which contains the location and the type of activity that enterprises developed in Colombia by 2016. Commerce spots are geo-referenced using the *Directorio Nacional de Empresas* address and name variables, and a concentration measure is calculated per block area.[2]

Figure 1 presents the spatial distribution of commercial activity in the city of Bogotá, where darker blue spots indicate a higher accumulation of commerce establishments per square kilometre. In this map, orange spots account for smoking prevalence by block, coming from the household survey described below.

2.2.2 Households

This paper uses a repeated cross-section database collected by DANE. For 2007, it uses the ECVB, whereas for 2011 the EMB is used as DANE built the database based on the ECVB. The outcome used to assess the effect of the law is household smoking prevalence. However, the surveys do not ask the same question regarding smoking prevalence in both waves. To overcome the challenges that this issue presents, some assumptions and calculations were made.

The ECVB-2007 has no information on individual smoking habits, while there is information on monthly tobacco expenditure by household. As it can happen that a household that spends in tobacco products does not consume them, we assume that a household that reports expenditure on tobacco products has at least one individual that smokes, thus, the household can be classified as a smoker household. On the other hand, EMB-2011 has information on smoking habits on a 30-day basis. In this sense, we can classify a household into the smoking category when at least one individual within the household had smoked in the last 30 days.[3]

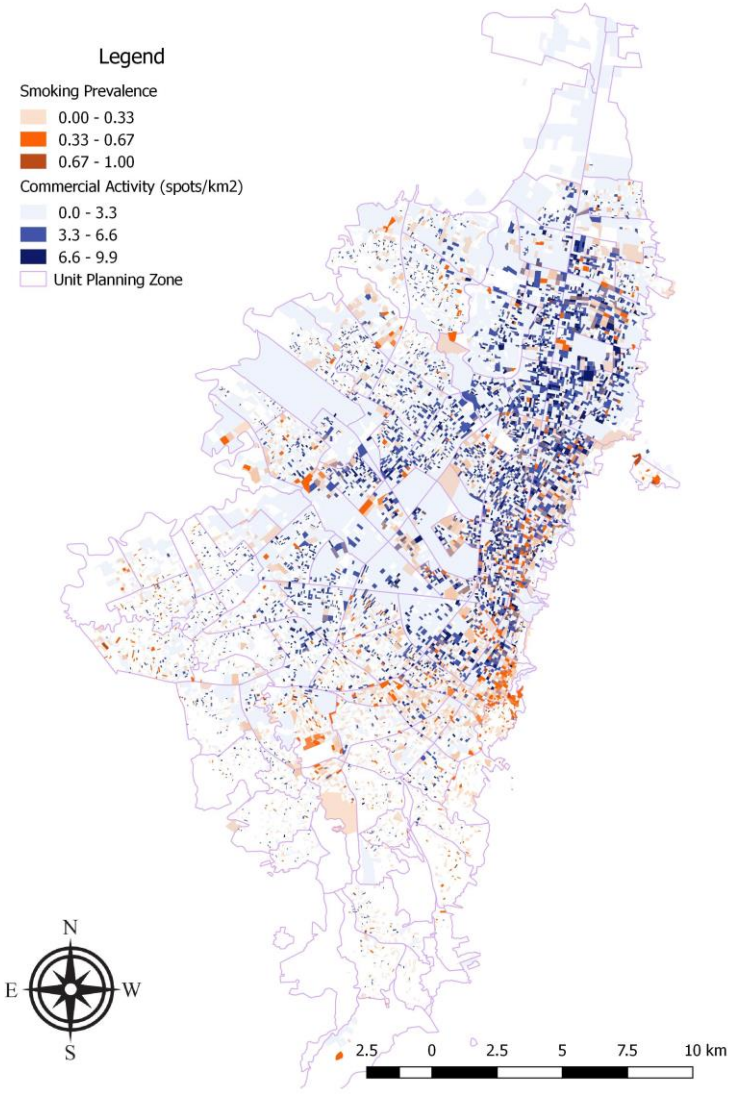
These data sets also contain information on demographics at the individual level (age, gender, educational level, household composition) and household location.

[2] The database was filtered to use commercial places related to the hospitality industry, restaurants, bars, cafes, and nightlife spots, among others.

[3] To validate that both years are comparable, prevalence is calculated using the tobacco expenditure assumption for the year 2011 and it was found that it replicates smoking prevalence as when the question related to 30-days smoking habits is used.

Expenditure information is only available at the household level. Thus, this research imputes household heads' socio-demographic characteristics to each unit of observation (household). Table 1 presents descriptive statistics by year and intention to be treated. As commercial density will be used to explore the heterogeneous effects of exposure intensity, descriptive statistics are also presented using a high or low commercial density.

Figure 1: Commerce Sector and Smoking Prevalence



Source: ECVB 2007, EMB 2011, Directorio Nacional de Empresas (DANE). Author's calculations.

Table 1: Descriptive Statistics by Year and Treatment Assignment

	Mean							
	2007				2011			
	Near		Far		Near		Far	
Variable	Low	High	Low	High	Low	High	Low	High
Panel A. Socio-demographic Characteristics								
Age	47.448	47.188	45.665	44.787	48.293***	48.799**	46.056	46.100
Gender	0.359	0.373	0.334	0.310	0.373*	0.393***	0.373	0.390
Household Composition								
Ratio Kids/Adults	0.427	0.403	0.641	0.655	0.403***	0.361***	0.576	0.502

Total individuals	3.242	3.135	3.754	3.764	3.222	3.060***	3.652	3.505
Educational Level								
Primary	0.381	0.336	0.657	0.649	0.231***	0.183***	0.403	0.364
Secondary	0.184	0.178	0.200	0.197	0.374***	0.315***	0.452	0.440
Tertiary	0.435	0.485	0.143	0.154	0.417**	0.523***	0.155	0.213
Commuting								
Commuting time	0.567	0.552	0.735	0.747	0.606***	0.620***	0.704	0.668
Commuted distance (aprox.)	11.770	11.604	14.495	14.784	13.143***	13.914***	14.085	13.662
Income Quintile								
Quintile 1	0.175	0.158	0.258	0.266	0.181	0.144*	0.283	0.237
Quintile 2	0.175	0.154	0.292	0.284	0.180	0.146*	0.279	0.255
Quintile 3	0.193	0.182	0.237	0.233	0.194	0.175	0.225	0.243
Quintile 4	0.220	0.235	0.145	0.134	0.227	0.234***	0.124	0.175
Quintile 5	0.238	0.271	0.069	0.084	0.218***	0.301	0.089	0.091
Panel B. Outcome and Treatment Variables								
Distance (nearest)	63.678	50.874	869.502	879.668	69.484***	43.033***	903.496	566.513
Commercial Density (nearest)	0.643	55.118	0.510	5.245	0.000***	2.880***	0.000	2.811
Prevalence	0.196	0.192	0.203	0.234	0.181***	0.171***	0.198	0.176
Observations	12136	6816	4947	2172	6994	4240	4085	938

Source: ECVB 2007, EMB2011, and DANE's Commercial Database

Notes: Near and Far correspond to the extent in which a household is exposed to tobacco use, given their closeness to commercial activity. A household is classified as being Near if the distance from the household block to the nearest commercial block is lower than the average distance (60 meters approximately), otherwise, it is classified as being Far High and Low correspond to the intensity in which commercial activity affects households, high accounts for 5 establishments per squared kilometer, and low accounts for 0.5 establishments, on average. Gender is a dummy variable, where female is one and male is zero. Commuting time is measured as a fraction of an hour, while commuted distance is expressed in kilometers. Distance represents the distance of a household to the nearest commercial spot in its surroundings, and it is measured in meters, while commercial density is measured as the number of commercial spots within a block by block's total area. Prevalence corresponds to the probability of a household being a smoker or the proportion of households that are classified as smokers in each year. A difference in means is conducted across time, and stars correspond to $^{*}p < .1$, $^{**}p < .05$, $^{***}p < .01$

Household heads (HHs) living far from commercial activity are younger than their counterparts, their ages are approximately 45.4 (2007) and 46.1 (2011), respectively, while HH in households that are far from commercial activity are approximately 47.4 and 48.5 years old in 2007 and 2011, respectively.

A higher proportion of women HHs are found near commerce spots (36% in 2007) than women HHs far from commerce (32% in 2007). The ratio of kids over adults decreased (from 0.48 to 0.44, on average), while the number of individuals within the household remained almost constant across time, although there are differences in treatment assignments. On education, there are vast differences between near and far households moving toward intermediate levels, for both 2007 and 2011. There are no significant differences in income quintiles between both surveys, while there are differences between treatment assignment.

Commuting represents a problem in our setting. Since household members may spend most of their time at their study and workplaces, there are differences in their levels of exposure to tobacco use. The average commuting time is less than an hour, which is slightly lower than the average commuting time for big cities in Latin America (CAF, 2010). Additionally, household members who live near commerce spots tend to take less time to reach their workplaces or places of study, than household members that live far from commercial activity. In terms of distance traveled, the difference between near and far households is approximately 1 to 3 kilometers, depending on the year. However, this measure is approximative since it is constructed using the average speed of different means of transport (CAF, 2010).

As shown in Panel B of Table 1, the average distance to commercial spots for households located near commercial activity is around 60 meters (less than a block), while for the households that are far from commercial activity, the average distance is between 840 and 873 meters, which account for ten blocks, approximately. In terms of prevalence, smoking has decreased, with higher decreases for households that are near commercial establishments.

5 Empirical Strategy

We estimate the effect of the smoke-free environment tobacco control policy implemented by the government in 2009 on households' smoking prevalence in the city of Bogotá. In order to do this, we implement a matching difference-in-differences, following Blundell and Dias (2009).

2.3.1 Matching technique

To assess variations which are representative of similar households, and considering that only two waves of information are available, preventing testing of the common trend assumption, a Kernel Propensity Score Matching with common support grouping by city area (administrative boroughs of the cities were grouped into five areas: north, central-west, central-east, south-west and south-east). The technique selects and weighs households before and after the intervention, distance to commercial blocks (near and far), and commercial density (low and high) to make them comparable in the following characteristics: age, gender, education level, household composition, and commuting. Further details are available in the online appendix B.

After matching, all variables were balanced between waves and across treatment (near and far). Table 2 shows that there are significant differences only in terms of commercial density, with lower commercial activity in 2011; and household size, with fewer household members in 2011.

Table 2: Sample Balance—Matching by City Area, Distance to Commercial Areas, and Commercial Density

	Mean							
	2007				2011			
	Near		Far		Near		Far	
Variable	Low	High	Low	High	Low	High	Low	High
Panel A. Socio-demographic Characteristics								
Age	47.349	48.953	44.739	44.232	47.165	47.261	44.208	43.765
Gender	0.343	0.354	0.335	0.376	0.351	0.358	0.345	0.363
Household Composition								
Ratio Kids/Adults	0.444	0.389	0.579	0.575	0.443	0.407	0.624	0.605
Total individuals	3.436	3.256	3.830	3.861	3.412	3.280	3.792	3.694
Educational Level								
Primary	0.194	0.133	0.391	0.406	0.197	0.179	0.385	0.432
Secondary	0.355	0.340	0.442	0.421	0.360	0.250*	0.461	0.336
Tertiary	0.451	0.528	0.166	0.173	0.443	0.571*	0.155	0.232
Commuting								
Commuting time	0.583	0.646	0.681	0.609	0.586	0.593*	0.674	0.671
Commuted distance (aprox.)	12.730	15.137	13.876	12.138	12.820	13.328*	13.728	13.566
Income Quintile								
Quintile 1	0.137	0.099	0.237	0.189	0.134	0.097	0.241	0.178
Quintile 2	0.170	0.133	0.272	0.270	0.174	0.132	0.289	0.273
Quintile 3	0.196	0.170	0.247	0.237	0.201	0.175	0.231	0.230
Quintile 4	0.236	0.252	0.145	0.207	0.239	0.249	0.145	0.208
Quintile 5	0.260	0.346	0.100	0.096	0.252	0.348	0.094	0.112
Panel B. Outcome and Treatment Variables								
Distance (nearest)	61.782	44.991	739.277	585.849	62.064	38.755	723.779	623.582
Commercial Density (nearest)	0.000	3.704	0.000	3.744	0.000	3.153	0.000	3.503
Prevalence	0.200	0.155	0.193	0.222	0.183*	0.172	0.196	0.167
Observations	3911	4490	1144	996	4461	2722	1646	366

Source: ECVB 2007, EMB2011, and DANE's Commercial Database

Notes: Near and Far correspond to the extent in which a household is exposed to tobacco use, given their closeness to commercial activity. A household is classified as being Near, if the distance from the household block to the nearest commercial block is lower than the average distance, it is classified as being Far otherwise. High and Low correspond to the intensity in which commercial activity affects households. Gender is a dummy variable, where female is one and male is zero. Commuting time is measured as a fraction of an hour, while commuted distance is expressed in kilometers. Distance represents the distance of a household to the nearest commercial spot in its surroundings, and it is measured in meters, while commercial density is measured as the number of commercial spots within a block by block's total area. A standardized difference test is conducted after matching and stars correspond to * variance ratio in [0.5, 0.8) or (1.25, 2] and ** variance ratio <0.5 or >2.

2.3.2 Difference-in-differences: Distance to commercial areas

To explore the impact of the smoke-free environment policy on smoking prevalence at the household level, we use a Difference-in-Differences strategy, stating the following:

$$y_{hbpt} = \delta_1 Dist_b^p + \delta_2 Post_t + \theta\left(Dist_b^p \cdot Post_t\right) + \beta_0 X_h + \eta_p + v_{hbt} \quad (1)$$

Where y_{hbpt} is the smoking prevalence of household h, located in block b, local area p at time t;[4] η_p are local area fixed effects to account for local area observable and unobservable characteristics that do not change over time. Variable $Dist_b^n$ takes the value of 1 if it is in lower half of the distance variable, regardless of its density. We also try other definitions of proximity in the robustness checks. This specification includes controls at the household level that are not affected by the treatment, such as share of women, age, level of education, kids to adults ratio, among others (X_h). Errors are clustered at the local area level (v_{hbt}). The parameter of interest under this specification is θ which shows the causal effect on smoking behavior in households near commerce spots, after the implementation of the law

One would expect θ to take a negative value, since increased exposure to commerce after the intervention implies that smoking is forbidden in indoor spaces and advertising is banned. Thus, household members should be less exposed to tobacco use and market strategies that affect their consumption. In this sense, being near commercial activity would have positive impacts on prevalence, such that there is a decrease in the number of people who smoke.

2.3.3 Triple-difference estimator: Density of commercial areas

We explore whether variation in density affects household smoking prevalence, as it has been shown that there is variation in distance and density within a small geographical area at the same time. In order to explore heterogeneous effects by intensity (high or low), this research used a triple-difference specification:

$$y_{hbpt} = \delta_1 Dist_b^p + \delta_2 Post_t + \delta_3 Dens_b^p \quad (2)$$

$$+ \gamma_1\left(Dist_b^p \cdot Post_t\right) + \gamma_2\left(Dist_b^p \cdot Dens_b^p\right) + \gamma_3\left(Post_t \cdot Dens_b^p\right)$$

$$+ \theta\left(Dist_b^p \cdot Post_t \cdot Dens_b^p\right) + \beta' X_h + \eta_p + \varepsilon_{hbt}$$

where $Dens_b^p$ measures the commerce density of the nearest block b. In the same sense as the distance specification, the definition of highly dense is a dichotomous variable that takes the value of 1 when the nearest commercial block has more than 2.2 commerce spots (higher than its average). All other variables remain as before. Thus, being near a spot that has a higher density, after the implementation of the regulation, would have a more significant effect on smoking behavior if $\hat{\theta}$ takes a greater negative value with respect to $\hat{\gamma}_1$.

[4] Local areas are based on the urban planning zones, which are a set of neighborhoods that share amenities and characteristics in terms of land use and economic activity. Each of them has an average of 64,600 inhabitants, and there are 113 of them.

6 Results

7 Main Results

If the policy was effective, one would expect to find reductions in household smoking prevalence. People who are close to commercial blocks would be less spatially exposed to tobacco consumption and would experience lower advertising awareness. As a result of lower take-up habits, increases in the cost of consumption in indoor spaces, and the internalization of the de-normalization of smoking behavior as a social norm, there would be a reduction in prevalence.

The results present the effect of the smoke-free environment policy, using it as an exogenous source of variation to understand the dynamics of household smoking prevalence, using distance and density to commercial establishments as the dimensions in which spatial and social exposure takes place: First, the effect of close or distant proximity on the household smoking prevalence after the implementation of the policy is explored using the DiD strategy mentioned before. Second, heterogeneous effects on exposure intensity and socio-demographic characteristics will be presented. Third, robustness checks regarding the definition of treatment are conducted.

Being near or far is a dichotomous variable that takes the value of 1 if the household is near the commercial activity, i.e., if it is closer than 60 meters which is the average distance in the whole sample. We show that results align with the proximity definition; Table 3 presents the results for four specifications, in which matching weights, block fixed effects, and controls are progressively included.

Since a matching technique is used to ensure identification in a DiD model, it may be necessary to observe what would have happened if we did not consider that units are different on observable characteristics before and after the intervention, and intention to be treated (near or far). As shown in Table 3 column (1), being in 2011 is negatively correlated with smoking prevalence, showing that there is a decreasing trend of smoking in Colombia. However, the closer the household is to commercial activity, the more likely it is for the household to smoke. The joint effect shows that after the implementation of the policy, being near to commerce, i.e., being more exposed to tobacco consumption leads to a non-significant effect of the smoke-free environment policy on the prevalence of 0.5 percentage points (pp.), under an unmatched sample.

After matching on observable characteristics, results that were present under the unmatched sample estimation remain constant. In Table 3, column (2), urban planning zones fixed effects and controls for several socio-demographic characteristics are included. There has been a decreasing trend in smoking prevalence over time. Close proximity to commercial activity after the intervention, which implies that one should be exposed to less consumption, given that smoking is forbidden in indoor spaces, has has resulted in a non-significant increase in smoking prevalence (about 0.014 pp.). Considering trends in the control variables, the trend in smoking prevalence is reversed and the effect, while still non-statistically different from zero, is negative.

Table 3: Difference-in-differences Results—Distance

	(1)	(2)	(3)	(4)
	Prevalence	Prevalence	Prevalence	Prevalence
DistM	0.0273***	−0.00826	0.00310	−0.0133
	(0.00964)	(0.0185)	(0.0185)	(0.0182)
Post	−0.0312***	−0.0167*	0.199***	0.144***
	(0.00616)	(0.00925)	(0.0212)	(0.0323)
DistXPost	−0.0109	0.00415	−0.00611	0.0120
	(0.0132)	(0.0221)	(0.0216)	(0.0216)
Dep. Mean	0.199	0.198	0.198	0.198
Dep. SD	0.400	0.399	0.399	0.399
Observations	21409	19569	19569	19569
Blocks	2739	2514	2514	2514
Local Areas	100	100	100	100
Matching weights	No	Yes	Yes	Yes
Robust errors	Yes	No	No	No
Local areas FE	No	Yes	Yes	Yes
Controls	No	Yes	No	Yes
Inter. Controls	No	No	Yes	Yes

Note: Clustered at local area (UPZ) standard errors in parentheses. Significance: * $p < .1$, ** $p < .05$, *** $p < .01$

Column (4) presents a complete specification, in which controls are introduced in levels and have interacted over time to account for tendencies in all observable socio-demographic characteristics. As previously noted, close proximity to a commerce spot after the implementation of the law presents a non-significant increase of 1.2 pp. in household smoking prevalence (i.e., household prevalence does not vary due to the implementation of the law). These results consider distance as the only source of variation that explains how being exposed to tobacco usage affects a household's smoking dynamics at the extensive margin.

When taking density into account (Table 4), the effect is deepened and becomes significant. Then the household smoking prevalence (having at least one smoker within the household members) is reduced for households that are near to highly dense commercial blocks, compared to households that are near to commercial places with low density in 9.6 pp. independently of the specification, since being spatially and socially exposed to cigarette use to a lesser extent discourages take-up habits and permanence. Since the results are significant for the specification stated in Equation 2, the rest of the paper will focus on the distance plus density result to explore socio-demographic heterogeneous effects and robustness checks.

Table 4: Difference-in-differences Results

	(1)	(2)	(3)	(4)
	Prevalence	Prevalence	Prevalence	Prevalence
Dist	0.00674	−0.0268	−0.0178	−0.0308
	(0.0132)	(0.0214)	(0.0207)	(0.0206)
Post	0.0309***	−0.0274**	0.186***	0.135***
	(0.00864)	(0.0105)	(0.0216)	(0.0328)
DensM	−0.00628	−0.0404**	−0.0445**	−0.0388**
	(0.00880)	(0.0182))	(0.0185)	(0.0178)
DistXDensXPost	−0.0367	−0.101**	−0.108**	−0.0962**
	(0.0273)	(0.0464)	(0.0462)	(0.0463)
DensXDist	0.0431**	0.0770**	0.0852**	0.0735**
	(0.0194)	(0.0373)	(0.0370)	(0.0366)
DistXPost	0.00668	0.0272	0.0191	0.0334
	(0.0172)	(0.0246)	(0.0236)	(0.0234)
DensXPost	−0.00252	0.0315*	0.0383**	0.0313*
	(0.0124)	(0.0176)	(0.0177)	(0.0174)
Dep. Mean	0.199	0.198	0.198	0.198
Dep. SD	0.400	0.399	0.399	0.399
Observations	21409	19569	19569	19569
Blocks	2739	2514	2514	2514
Local Areas	100	100	100	100
Matching weights	No	Yes	Yes	Yes
Robust errors	Yes	No	No	No
Local areas FE	No	Yes	Yes	Yes
Controls	No	Yes	No	Yes
Inter. Controls	No	No	Yes	Yes

Note: Clustered at local area (UPZ) standard errors in parentheses. Significance: * $p < .1$, ** $p < .05$, *** $p < .01$

8 Heterogeneous Effects

To deepen the analysis on whether there is any social convention that affects smoking behavior at the household level, some exercises of heterogeneous effects by age group, children at home, and occupation of the HHs were set.

Table 5 presents the estimation of the most complete specification of the model, i.e. column (4) of Table 3, including the heterogeneous effects as described above. Columns (1) and (2) present the results by age group, defining "young" as HHs younger than 45 years old and "old" as HHs older than 45 years. It has been shown that the longer the habit, the more difficult the cessation process is (Becker and Murphy, 1988; Douglas, 1998) since tobacco use is an addictive behavior. As age might be associated with the level of addiction and the duration of the habit, one would expect that after the implementation of the law, households that are older (with older HHs) are less sensitive to the policy. Therefore, younger people would be more responsive to a smoke-free environment intervention. Yet, for younger or older HHs, the difference is statistically the same, but more precisely estimated for the older HHs.

Table 5: Difference-in-differences Results—Heterogeneous Effects

	Age Group		Kids at home		Occupation	
Variable	Young	Old	No Kids	Kids	Unskilled	Skilled
	(1)	(2)	(3)	(4)	(5)	(6)
Dist	−0.0257	−0.0285	−0.0351	−0.0292∗	−0.0292	−0.0276
	(0.0210)	(0.0399)	(0.0500)	(0.0173)	(0.0379)	(0.0229)
Post	0.135∗∗∗	0.0643	0.159∗∗∗	0.0975∗∗	0.0557	0.145∗∗∗
	(0.0473)	(0.0811)	(0.0407)	(0.0472)	(0.0616)	(0.0375)
DistXDensXPost	−0.0782	−0.130∗	−0.0311	−0.134∗∗	0.0386	−0.112∗
	(0.0528)	(0.0683)	(0.0939)	(0.0537)	(0.0661)	(0.0569)
DensXDist	0.0414	0.137∗∗	0.0322	0.104∗∗	0.0264	0.0858∗
	(0.0338)	(0.0637)	(0.0813)	(0.0402)	(0.0508)	(0.0455)
DistXPost	0.0232	0.0462	0.0323	0.0334	0.0440	0.0229
	(0.0267)	(0.0405)	(0.0558)	(0.0221)	(0.0432)	(0.0263)
Dep. Mean	0.212	0.175	0.199	0.198	0.210	0.193
Dep. SD	0.409	0.380	0.399	0.399	0.408	0.395
Observations	12352	7217	8126	11443	6129	13440
Blocks	1542	962	1104	1415	829	1686
Local Areas	100	100	100	100	100	100
Matching weights	Yes	Yes	Yes	Yes	Yes	Yes
Local Areas FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Inter. Controls	Yes	Yes	Yes	Yes	Yes	Yes

Note: Age is a binary variable that takes the value of 1 if the household head is younger than 45 years old and zero otherwise. Kids is also a binary variable that takes the value of 1 if there are children in the household, and zero in any other case. Finally, Skilled indicates if the household head has a white collar occupation, which is defined by education and occupation; an individual is skilled if s/he is occupied, has a greater educational level than primary and her(his) occupation is government worker, self-employed, and/or boss. Clustered at local area (UPZ) standard errors in parentheses. Significance: $^{*}p < .1$, $^{**}p < .05$, $^{***}p < .01$

Columns (3) and (4) of Table 5 show the estimation by household composition in terms of children, defining Kids if there are one or more children living in the household, and no Kids in any other case. The evidence of the relationship between parents' smoking behavior and their household composition is scarce and inconclusive. There is evidence of tobacco use reductions in pregnant women (Lumley et al., 2009; Kendrick et al., 1995; McBride and Pirie, 1990), higher intentions to reduce smoking in indoor spaces by parents to avoid exposing their children to cigarette smoke (SynnØve Moan et al., 2005), and on the effects on

initiation of children who grow up with tobacco smoking role models (e.g., parents) (Collins et al., 1987; Tucker et al., 2002). Thus, children are affected by their parents' smoking behavior, and parents' decision to smoke can be influenced by having children. In this sense, having children at home can generate additional costs for parents when deciding to smoke. Evidence is also imprecise under the exercise developed in this research. There is a significant net reduction of 13.4 pp in household smoking prevalence when there is at least one child compared to families with no kids (−3.11 pp, non-significant).

Finally, Columns (5) and (6) display the results by occupation. Occupation is divided into skilled and unskilled labor. Skilled labor, is defined by education and occupation simultaneously; an individual is classified as skilled if s(he) has an occupation, has a higher educational level than secondary education, and her(his) occupation is one of the following: government worker, self-employed, or an executive or worker in a company. One could consider that people might respond differently depending on their occupation. Assuming that skilled workers purchase their cigarettes at the legal commerce sector and work in zones that are commercially dense (for the case of Bogotá), one would expect that the law would have greater impact on their cigarette consumption. Skilled workers reduce their smoking prevalence more than unskilled HHs (-11.2 pp vs. non-significant +3.8 pp).

9 Robustness Checks

3.3.1 Sensitivity analysis

The threshold that classifies observations into the treated and control groups is *ad hoc*. Therefore, we consider different alternatives to assess the sensitivity of the results to such arbitrary values. Figure 4 presents the estimated effect of being near a highly dense commercial block after the implementation of the law, i.e., using the second specification of the model. In this sensitivity analysis, density is defined using the previous average density plus an arbitrary value between −1 and 1; that is, setting the threshold between 1.2 and 3.2 commerce spots per square kilometer, with breaks of 0.1. For graphical representation, we normalized the cutoff to zero when using the average density.

The effect varies and is near 8.5 pp. for households that are near high-density commercial blocks compared to households that are near low-density commercial blocks. Some cases appeared to be statistically significant when we defined the threshold as a lower value than the city's average density. However, the effect disappears when the threshold is set over the average density because the number of observations available is reduced, increasing the standard error; the opposite happens to the left; however, the estimated coefficient is stable.

3.3.2 Placebo test

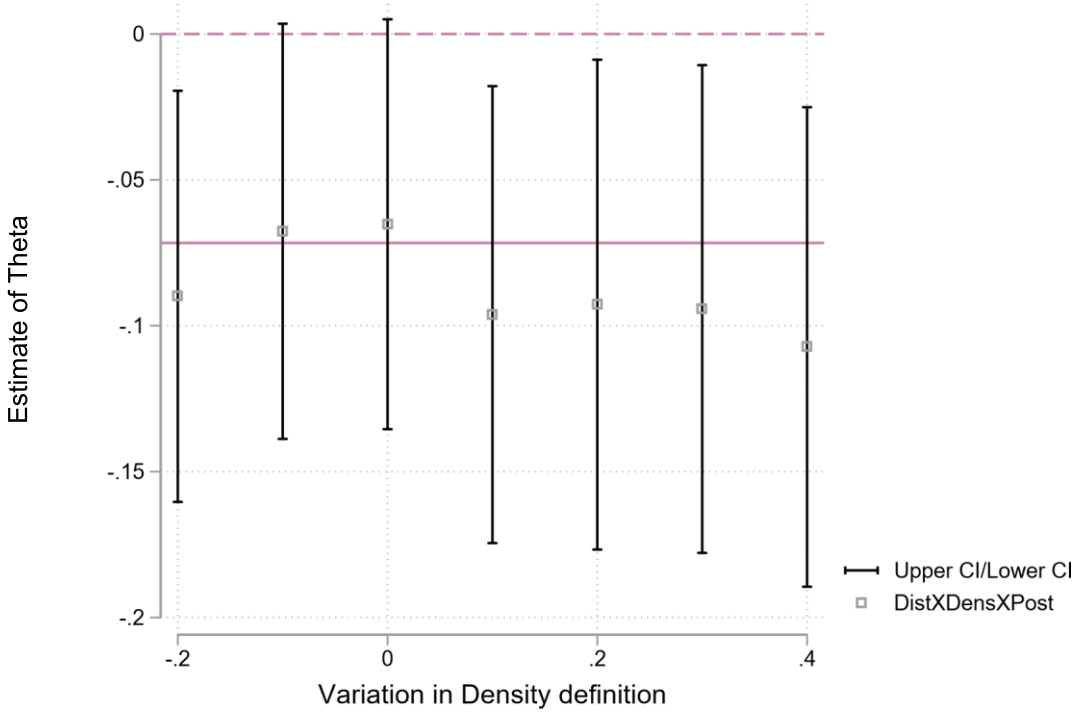
Finally, a placebo test is performed to verify that distance, as the variable for the treatment assignment, does not influence the results. The exercise is conducted in two ways: The first one consists of randomly assigning values to the high and low-density dummy, by drawing artificial density values from a uniform distribution between zero and five.[5] In this case, the distance variable is not modified. The second way is defining both distance and density dummies randomly. As presented in the empirical strategy, the near dummy is constructed using households' average distance to their closest commercial block. However, in this exercise, distance is randomly allocated from a uniform distribution, between 0 and 800 meters. [6]

Both procedures are executed a hundred times; the histograms below present the estimations. The estimate of this research is not contained in the domain of the estimates produced by this exercise (Figures 5 and 6), so it aligns with the definition of distance and density used previously to identify whether households are exposed to the policy and intended to be treated.

[5] Five is the average continuous density measure of the high-density category.

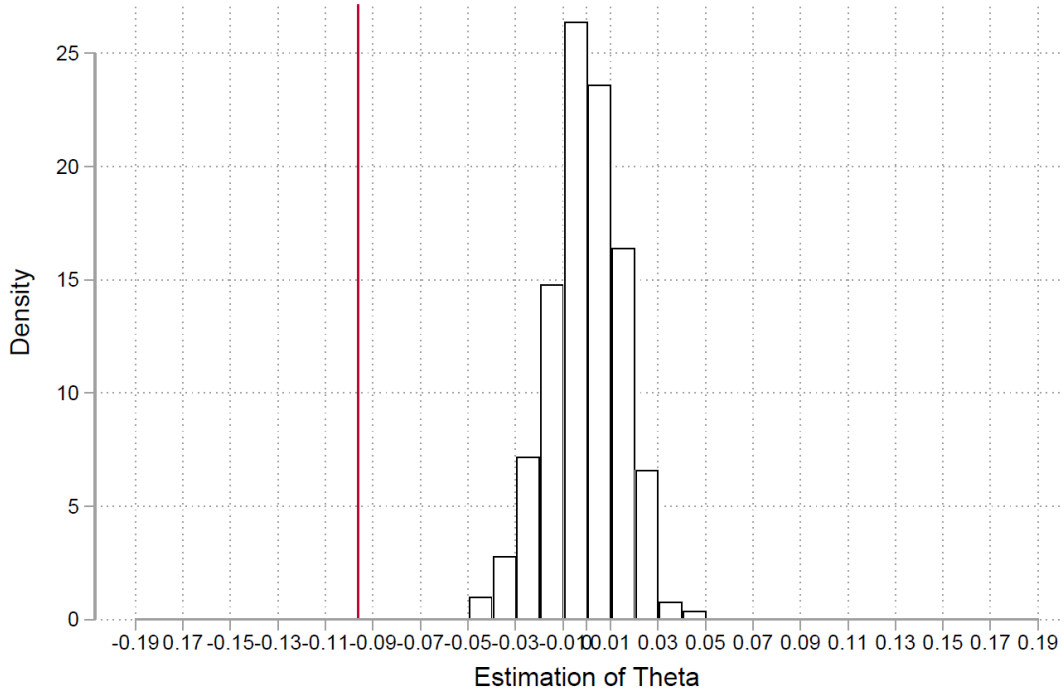
[6] 800 is the average continuous distance measure of the far category.

Figure 4: Sensitivity Analysis—Density



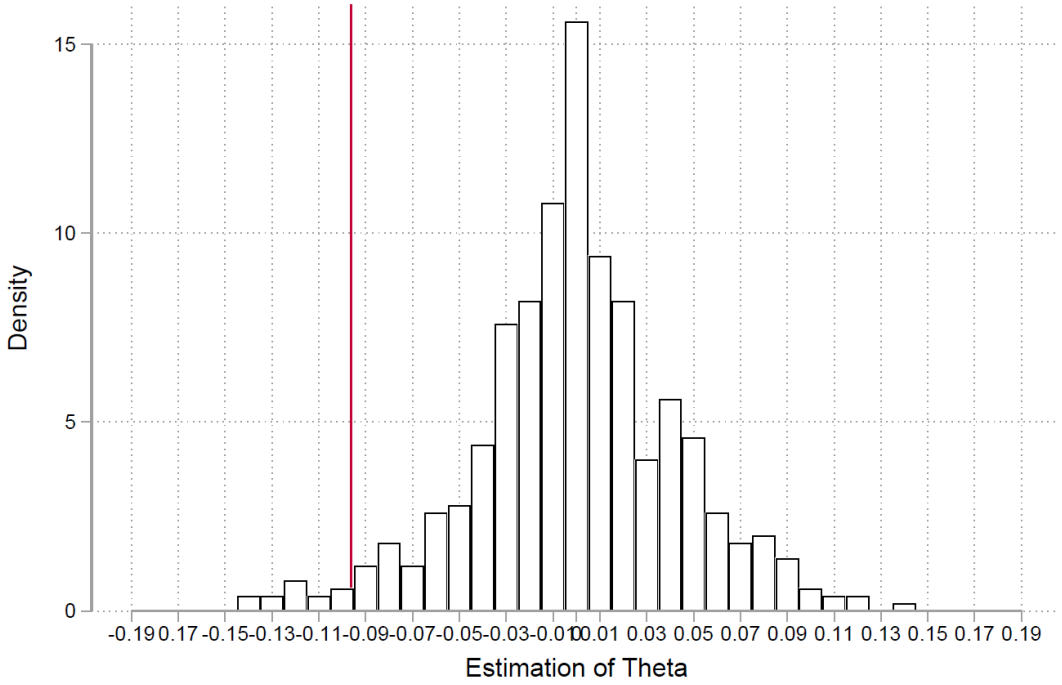
Note: Density is defined using the average density as before plus an arbitrary value between −0.4 and 0.4, with breaks of 0.1. For graphical representation, we normalize the cutoff to zero when using the average density.

Figure 5: Placebo Test—Distance



Note: Distance is randomly drawn from a uniform distribution, between 0 and 800 meters. This procedure is executed 500 times. The vertical line corresponds to the main point estimate.

Figure 6: Placebo Test—Distance + Density



Note: Both distance and density are drawn from uniform distributions. Distance between 0 and 800 meters, and density between 0 and 5. This procedure was executed 500 times. The vertical line corresponds to the main point estimate.

10 Discussion

4.1 Interpretation

This research estimates the effect of a smoke-free environment tobacco control policy on households' smoking behavior in Bogotá, a big city in a middle-income country. It considers the spatial exposure of households to tobacco use, by exploiting a DiD strategy and exploring the heterogenous effects of exposure intensity. It also presents and discusses diverse transmission mechanisms through which distance and density may affect household smoking behavior. It was found that there is a decrease in household smoking prevalence (which is consistent with the treatment assignment rule) when the commercial density is assumed to be affecting the consumption decisions of household members. This means that households that are near highly dense commercial blocks reduce their smoking prevalence more than households near to lowly dense commercial blocks to around 9.6 pp., which is a significant reduction from a smoking prevalence of 19.2% in 2007. As the law reduces the usage of tobacco in commercial establishments, being less spatially (and socially) exposed to cigarette use discourages lighting up, which might happen as a result

of an internalization process of the law, and lower valuation of smoking as a whole, since social consumption is discouraged.

This research sheds light on three socio-demographic results that the literature has presented. Firstly, longer habit duration makes cessation processes more difficult, since tobacco use is an addictive behavior (Douglas and Hariharan, 1994; Becker and Murphy, 1988). Therefore, the age of individuals is positively correlated with tobacco use. In contrast, this paper finds no difference for households whose head is classified as young, compared to old HHs. Secondly, in terms of household composition, having children at home can generate additional costs for parents when deciding to smoke (SynnØve Moan et al., 2005). Hence, if parents' smoking behavior is seen as an influence to their kids' health, prevalence reductions could be attributed to a pro-social internalization of the norm (Bicchieri and Chavez, 2010; Krupka and Weber, 2013, 2009). This paper finds statistically significant evidence of household smoking prevalence reductions of 13.4 percentage points on average, when there is at least one child at home; a reduction not present for households without children. Finally, the literature has also shown that higher socioeconomic status leads to lower tobacco consumption (Chaloupka et al., 2011; Farrelly et al., 2001). In this sense, it is found that skilled HHs, who have higher educational and occupational levels, reduce their smoking prevalence to around 11.2 percentage points; which does not happen for their unskilled household pairs. We hypothesize that this is linked to their higher probability of purchasing cigarettes at the legal commercial sector.

4.2 Limitations

In understanding how public smoking bans affect smoking behavior, there were some limitations considering the context and the data used.

First, by considering household-level data, our analysis cannot detect changes in the number of cigarettes consumed (intensive margin), or even on the number of individuals who are smokers. Thus, we observed the variation coming from households were all smokers change their decision, which is a lower bound of the potential impact of the policy. Moreover, we cannot analyze the policy's role in other aspects of behavior, such as alcohol consumption or violence. Studies have shown unintended effects of public smoking bans such as an increase of alcohol intake (Burton, 2011; Adams and Cotti, 2008). This limits our ability to assess the policy's full welfare benefit, as alcohol intake is associated with increases on violence and road accidents, among other externalities.

Second, our 2016 business register does not allow us to identify whether the commerce spots were founded before 2009 when the policy came into force. However, there are reasons to believe that the spatial information of commerce observed in 2016 is a good proxy of its distribution before the law was implemented. There is anecdotal evidence on the consolidation of commercial zones that shows that distance to commercial spots was determined before the implementation of the policy. Urban consolidation dates from late 20th century (Mercado, 2019), and the routes of the main mass intervention (Transmilenio), which could affect the spatial distribution of commerce, were finished by 2006. However, in terms of commercial density, it is not clear whether the commercial activity, related to the purchase and consumption of tobacco, has grown or decreased during the period of study. In particular, retail commerce grew by 4.85% on average from the first quarter of 2007 to the fourth quarter of 2011; but decreased by 3.36% when the intervention was initiated (2009). Additionally, this measure does not uniquely identify commerce spots related to tobacco use, although this type of commerce (bars, restaurants, neighborhood shops, among others) account for 90% of retail activity.

Third, Colombia exhibits large informal commercial activity that may counter the effect on prevalence, through a channel of availability of purchase and consumption at the informal sector. Colombia has a large shadow economy, where commercial informality is close to 45% (DANE, 2017). In particular, the informal sector holds a market share of 50% of tobacco sales and is considered one of the main providers of cigarettes by unit (Maldonado et al., 2018). Given that the law prohibits indoor consumption and stick sales, the informal sector plays an important role in households' cigarette consumption dynamics, as the enforcement of the law in the informal sector is low. Thus, tobacco purchase and consumption could have been displaced from formal to informal commerce, which might imply a lower impact on prevalence. In this sense, the estimate of the reduction in household smoking prevalence found in this study is a lower bound of the potential effect of such a policy. If the law were correctly enforced in the informal sector, the availability of purchase and consumption in that sector would be reduced, as in the formal sector. Therefore, the social value of cigarette use would be lower, generating greater reductions in household smoking prevalence.

11 Conclusions

We found that the public smoking ban in Colombia resulted in a significant reduction in smoking prevalence (−9.6 pp.) among households that were previously more exposed to the social norm by living close to highly dense commercial areas in the city. The impact is larger for households with children, who are more educated. Therefore, we can conclude that using a strategy that aims to de-normalize behaviors can reduce the threat posed by temptation goods in developing countries. It can be used to complement general public health strategies such as increased taxation. It may also be useful when rolling out cash transfers and other programs which could potentially result in increased consumption of temptation goods.

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A Transmission mechanisms: Contextualizing the effects

Unresolved questions in this paper include why and how the setting presented in this research would identify the effect of tobacco use exposure through proximity to commercial activity on household smoking prevalence. This section shows some of the possible transmission mechanisms to answer these queries. First, it explains why one could think that the law is enforced in commercial establishments. After that, it analyzes the mechanism through which household members would change their smoking behavior due to a smoke-free environment policy. Unfortunately, with the current data, it is not possible to disentangle these mechanisms.

A.1 Law enforcement in commercial establishments

The direct enforcement of the policy evaluated in this research, including clean indoor spaces, the prohibition of stick sales and restrictions on advertising, is challenging to implement. On the one hand, commerce spots could not comply with the policy to avoid losing sales and customers; on the other hand, individuals would not be willing to embrace the norm as it would affect social interaction while consuming cigarettes. The following two subsections analyze whether there is theoretical or empirical evidence of compliance with the norm from both perspectives.

Commerce self-enforcement

Punishments for establishments that do not adhere to the norm are settled in the law. However, proper enforcement of the law would require monitoring of all kinds of indoor spaces and commercial spots where cigarettes could be purchased and consumed. In this sense, the law's implementation and enforcement depend mainly on the owners of commercial establishments. Bogotá included the monitoring of smoke-free spaces in sanitary inspections and establishments complied with the law in 91% of the cases (Uang et al., 2018). Likewise, there is evidence that the Association of Bars supported the policy's implementation; they conducted an intense education exercise of the bar owners six months before the effective date of the law (Uang et al., 2018). In this sense, there is evidence of self-enforcement by business owners. Also, evidence from other countries shows that firms' revenues are not affected by complying with this type of norm, and there are improvements in public health (Pieroni and Salmasi, 2017).

Thus, if the businesses enforced the rule by themselves, it would imply that households near such commercial spaces would be forced to comply with the law. Household members would not buy per stick, would not consume their tobacco products at the moment of the purchase, and would be exposed to a lesser extent to advertising.

Smoking de-normalization and social norms

There are several behavioral mechanisms through which individuals could internalize the de-normalization of smoking and implement a smoke-free environment policy. Social norms could be seen as external costs when they go against the will of the individual, and therefore, there is a degree in which agents' actions comply with or contradict norm. An individual who knows and understands a norm can decide whether to comply with it or not (Krupka and Weber, 2013). Smokers may choose to refrain from lighting up in a public place for several reasons, including legal (fear of being penalized), or normative (fear of being accosted by someone in their vicinity), both of which lead to the same outcome (not lighting up). From the normative perspective, individuals could update the degree in which they comply with the law, according to how appropriate, fair, and applicable they consider the norm (Bicchieri and Chavez, 2010). In this sense, being highly spatially exposed to tobacco restrictions could affect the degree to which individuals consider the law to be applicable. Agents can update their probability of complying with the norm by obtaining information coming from the public efforts to discourage smoking and the de-normalization of the habit. In this sense, an individual who is exposed to tobacco use in a high commercial density area is well aware of the fact that smoking in indoor spaces is forbidden; this, in turn, reduces smoking by increasing the probability of compliance with the social norm.

A.2 Households' smoking and pro-social behavior

The mechanism through which a household would change its smoking behavior, due to a smoke-free environment policy, might include social norms and pro-social behavior. Smokers enjoy lighting up their cigarettes themselves and from social consumption, i.e., from sharing with others while they smoke. In this sense, if one could reduce the value attached to social consumption, smoking prevalence would decrease, since smoking, as a whole, would generate less welfare.

Perceived social norms and pro-social behavior

Smokers generate a negative externality on society. Thus, an analysis based on pro-social behavior would be adequate to analyze how household members would change their smoking behavior due to proximity to commercial activity. From the literature on pro-social behavior, one can identify two possible mechanisms through which social norms can explain the reduction of household smoking prevalence due to their closeness to commercial activity. First, one could think of a focusing mechanism, under which norms influence behavior only when they are primed with cues from the environment (Krupka and Weber, 2009). Thus, considering that a policy of smoke-free environments determines the conditions under which individuals should behave in public spaces, concerning their consumption of tobacco, agents adapt to the "appropriate" behavior established by the law, influenced by the context surrounding them. The social value of smoking is reduced, given that it is inappropriate to consume tobacco in public spaces, where social consumption occurs. Second, there could be an informational effect of the norm. Observing what others do informs what the agent is expected to do in the society, i.e., if one observes that others comply with the norm, he would comply. Then, if an individual is close to commercial zones with high-density commerce spots, that individual will be exposed more frequently to compliance with the norm compared to an individual who is far from, or less exposed to, commercial activity. Therefore, those who are most exposed to compliance with the law will have a lower probability of becoming smokers.

B Propensity Score Matching (PSM)

An important concern in comparing households that in close or distant proximity from commercial activity between 2007 and 2011 is the substantial composition effects: apart from time, the notorious reduction on smoking prevalence is not random. Panel A of Table 1 compares (a) near households of 2007, (b) far households of 2007, (c) near households of 2011, and (d) far households of 2011; all divided by density (high or low). The stars in the table reflect the significance of a means test of each group (b,) (c), and (d) against the reference (a).

The differences presented in the table motivate a matching exercise. The goal of this exercise is to replicate the characteristics of group (a) with the populations of groups (b), (c), and (d). For this, households of groups (b) ,(c), and (d) are weighted in such a way that their average resembles group (a) average for each of the following characteristics: household head age, gender and educational level, the ratio kids over adults, the imputed commuting distance and time, and the income quantile. Considering that there are two households from different geographical areas, they may have identical characteristics; however, they might not be comparable given their location. This paper pre-processes the data using a PSM technique with common support for each city area. City areas are defined over the boroughs/districts of the city: north-west (Suba), north-east (Usaquén, Chapinero, Barrios Unidos, Teusaquillo), central-west (Fontibón and Engativá), central-east (Santa Fe, Los Mártires, Puente Aranda, Rafael Uribe Uribe), south-west (Bosa, Kénnedy, Ciudad Bolívar, and Tunjuelito), south-east (San Cristóbal, Antonio Nariño, Usme). Rural areas of the city were not included in the analysis.

The PSM indicates the predicted probability that an observation is part of group (a) rather than the specific comparison group. Given it, the weights are selected in such a way that the kernel density of the PSM of group (a) and its comparison are the same.

After matching, differences in means are assessed by implementing a standardized difference in means test where variance ratios lower than 0.5 and greater than 2 indicate a bad fit. Figure 7 shows that the distribution of bias is reduced after implementing the procedure.

Figure 7: Matching Histogram of % of Bias