Tobacco Control Protocol and Household Smoking Behavior: The case of Bogotá, Colombia

Author:
Susana Otálvaro-Ramírez

Advisors:
Paul Rodríguez-Lesmes & Juan M. Gallego

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Marco para el Control del Tabaco y Tabaquismo de los Hogares

El caso de Bogotá, Colombia

Susana Otálvaro-Ramírez

Resumen

Comprender los efectos de las políticas de control del tabaco en la prevalencia del tabaquismo es de gran importancia en la salud pública. Estas políticas pueden mitigar el consumo, promover el abandono del hábito y promover los hábitos saludables. Este documento evalúa el efecto de una política de control del tabaco no relacionada precios, que no ha sido ampliamente estudiada en países de ingresos medios y bajos, sobre la prevalencia del tabaquismo en Bogotá, Colombia. También presenta algunos mecanismos de transmisión del impacto de una política de espacios libres de humo en la prevalencia a nivel del hogar. Utilizando datos de actividad comercial y de hogares, este documento estima el efecto de la política mediante la implementación de una estrategia de Diferencias en Diferencias. Considerando que la ley afecta directamente las áreas comerciales, afecta indirectamente la exposición física de las personas al consumo de tabaco. Luego, uno esperaría que las personas que están más cerca de las manzanas con actividad comercial, estén menos expuestas espacialmente al consumo de tabaco y experimenten una menor exposición publicitaria después de la implementación de la política. Lo anterior conduciría a una reducción en la prevalencia como resultado de hábitos de iniciación más bajos, un aumento en el costo de consumo en espacios cerrados y una reducción en la utilidad derivada del consumo social. Se encuentra que la prevalencia del tabaquismo se reduce para los hogares que se encuentran cerca de espacios comerciales con alta densidad de establecimientos, comparados con los hogares que están cerca de espacios comerciales con baja densidad, en relación con los hogares ubicados lejos del comercio, tras la implementación de la política. Dado que un hogar cercano con alta densidad comercial en sus alrededores estará expuesto con mayor frecuencia al cumplimiento de la norma que un hogar que está menos expuesto a la actividad comercial, los miembros del hogar cercano estarán más dispuestos a internalizar el proceso de des-normalización del tabaquismo y, por lo tanto, quien esté más expuesto al cumplimiento con la ley reducirá la probabilidad de ser fumador.

Palabras clave: Microeconomía, Salud Pública, Análisis a nivel de hogar

Clasificación JEL : D00, I18, R28

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Susana Otálvaro-Ramírez[†]

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Abstract

Understanding the effects of tobacco control policies on smoking prevalence is of great importance in public health. They may have effects on discouraging take-up, promoting smoking cessation, and enhancing healthy habits. This paper assesses the effect of a non-price related tobacco control policy, which has not been widely studied in low and middle-income countries, on smoking prevalence in Bogotá, Colombia. It also presents some transmission mechanisms of the impact of smoke-free environments on household smoking behavior. Using household and commercial activity data, this paper intends to estimate the effect of the policy on household smoking behavior by implementing a Difference-in-Differences strategy. Regarding that the law directly affects commercial areas and in this sense physical exposure of individuals to tobacco consumption, one would expect that people who are closer to commerce blocks would be less spatially exposed to tobacco use and experiencing lower advertising exposure after the implementation of the policy. It would lead to a reduction in prevalence as a result of smaller take-up habits, an increase in the cost of consumption in indoor spaces, and a reduction in utility derived from social consumption. It is found that smoking prevalence is reduced for households that are near highly dense commerce blocks, compared to households that are near to commercial places with low density, relative to far located households, after the implementation of the law. Since a near household will be exposed more frequently to compliance with the norm than a household that is far or less exposed to commercial activity, household members would be more willing to internalize the smoking de-normalization process and therefore, whoever is most exposed to compliance with the law will reduce the probability of being a smoker.

Keywords: Microeconomics, Public Health, Household Analysis

JEL Classification: D00, I18, R28

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[†]Faculty of Economics, Universidad del Rosario. e-mail: `susana.otalvaro@urosario.edu.co`

1 Introduction

Tobacco consumption is one of the biggest public health threats the world has ever faced, killing more than 7 million people a year (WHO, 2017). Therefore, it is of great importance in public health to understand the effects of tobacco control policies on smoking prevalence. Policies go from excise taxes to smoke-free environments and advertising bans and they have been shown to discourage take-up habits, promote smoking cessation, and enhance healthy habits (Chaloupka and Grossman, 1996; Farrelly et al., 2001; Douglas, 1998).

In this sense, the World Health Organization Framework Convention on Tobacco Control (WHO, 2005) promoted the implementation of meaningful tobacco control policies to prevent, discourage, and reduce smoking. As a result, many countries have developed price and non-price related control policies to address the issue. Some studies have examined the impact of taxes, smoke-free environment policies and education campaigns on smoking behavior (Chaloupka and Grossman, 1996; Farrelly et al., 2001; Franks et al., 2007; Siahpush et al., 2009; Chaloupka et al., 2011). However, non-price related policies, such as clean indoor spaces, have not yet been widely studied in low and middle-income countries, and there is no empirical evidence on the effectiveness of such policies in Colombia.

This paper assesses the effect of the Colombian non-price related tobacco control policy on household smoking behavior in Bogotá, at the extensive margin. For this analysis, the paper uses *Encuesta de Calidad de Vida de Bogotá 2007* (ECVB-2007), its paired survey, the *Encuestra Multipropósito de Bogotá 2011* (EMB-2011), and data on commercial activity. The household surveys contain information on household expenditures on different categories, including tobacco expenditure, which is used as an indirect measure of household smoking prevalence (construction of the measures are presented in more detail in Section 5).

This research also presents some transmission mechanisms that illustrate the effect of a non-price related smoke-free environment policy on household smoking behavior. These channels take into account the social cost of cigarette consumption and the learning of the policy as a social norm. After that, the effect of spatial exposure to tobacco use on household smoking prevalence is estimated by exploiting Colombia's government ordinance on smoke-free public spaces, advertising bans and stick sales prohibition, issued by Congress in July 2009. The objective of this law is to reduce potential harm on secondhand smokers, and diminish smoking behavior in general.

The law prohibits the consumption of cigarettes in public indoor spaces, like shops, restricts smoking advertising and bans sticks' sales (purchase by unit). Given that commerce

spots related to tobacco use and purchase are the most directly affected by this policy, this paper uses data on commercial activity to define whether a household is exposed to tobacco use in a greater or lower extent. In particular, it uses information on restaurants, bars, cafes, and nightlife spots. Given the above, and considering that information on household block location is available, the distance of households to commercially dense blocks is exploited to measure the intensity in which household members are exposed to tobacco use and therefore, intended to be treated.

This research uses a repeated cross-section database with two waves and implements a matching technique to achieve the balance between the households that are near blocks with commercial activity versus the households located far from commercial blocks, given that no information is available to conduct a test on the parallel trend assumption and to find the causal effect we must guarantee that there are no observable (and non-observable) characteristics that could drive the effect. Thereafter, a Difference-in-Differences (DD) strategy is employed to measure the effect of the ordinance on household smoking behavior. The DD strategy exploits the implementation of the smoke-free environment policy 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.

If the policy were effective, one would find that there are reductions in smoking prevalence. People who are close to commerce spots would be less spatially exposed to tobacco use and would experience lower advertising exposure. This reduction could happen as a result of lower take-up habits, the learning of the de-normalization of smoking ann the increase in the probability of compliance with the norm. In addition, being exposed in greater intensity (higher commercial density) can reduce the prevalence to a greater extent, since the commercial activity in the vicinity of the household is bigger and the law enforcement is noticeable.

The findings suggest that being near commercial activity does not significantly affect household smoking behavior (prevalence) as a result of the law implementation. However, there is an effect of the policy on their prevalence when the commercial density, to which a household is exposed, is assumed to be affecting the consumption decisions of its members, and therefore, their smoking prevalence. Being near to a commerce block, after the implementation of the law, reduces household smoking prevalence by 7.1 percentage points (pp.) more for households within a highly dense commerce block compared to lowly dense

exposed households. Consequently, as the law reduces the usage of tobacco at commercial establishments, being less spatially (and socially) exposed to cigarette use discourages take-up and the permanence of the habit.

In summary, this research assesses the effect of a smoke-free environment tobacco control policy on the smoking behavior of the population of Bogotá, a big city in a middle-income country. It intends to shed light on the effects of a non-pecuniary policy intervention on smoking, providing evidence on the impact of the policy at the extensive margin, by analyzing the possible mechanisms through which households might change their smoking behavior. The contributions of this research are, first, using households' spatial exposure to tobacco use (distance to and density of commerce spots) to evaluate the implementation of a smoke-free environment policy, by exploiting a Difference-in-Differences strategy and heterogeneous effects of spatial exposure intensity. Second, analyzing the impact of this type of policy on Colombian households' smoking behavior, illustrating how effective this policy is at the extensive margin. Third, this research explores diverse transmission mechanisms through which distance and density could affect household smoking behavior. In addition, it analyzes three socio-demographic results that the literature has presented. In terms of duration of habit, the literature has shown that longer smoking duration makes cessation processes more difficult, as it is an addictive behavior (Douglas and Hariharan, 1994; Becker and Murphy, 1988). Accordingly, this paper finds a higher smoking prevalence reduction for households whose head is classified as young, compared to old household heads. It has also been shown that the household composition is crucial in tobacco consumption decisions. Parents consider the wellbeing of their children when deciding to smoke, and/or children learn healthy or harmful behaviors from their parents. The evidence on this issue is inconclusive and this paper finds non-statistically significant evidence of household smoking prevalence reductions when there is one child at home, compared to households with no kids. 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 finds that skilled household heads, with higher educational and occupational levels, reduce their smoking prevalence more than their unskilled household pairs.

The rest of this document goes as follows. Section 2 presents the context in which the law was settled. Section 3 briefly discusses the literature review. Section 4 presents possible transmission mechanisms. Section 5 describes the data. Section 6 shows the empirical strategy that will be used to understand the effect of the law. Section 7 presents the results, heterogeneous effects on exposure intensity and socio-demographic characteristics. And section 8 discusses the results and concludes.

2 Context

Following the WHO Framework Convention on Tobacco Control, Colombia has responded to international conventions, regarding tobacco control policies, by undertaking several policies to curb tobacco consumption in favor of public health during the first two decades of the 21st century. Price and non-price related policies had taken place on the governmental agenda. On one hand, a non-price-related policy (Law 1335) was issued by Congress in July 2009. It had a smoke-free environment orientation, regarding that one of the main components, and the one that was implemented first, was "*Espacios Libres de Humo*", an initiative to curb tobacco use through the prohibition of consumption in indoor public places. This law also included restrictions on advertising and stick sales, which entered in place later on, in 2011.[1] On the other hand, the regulation of tobacco prices has changed several times in the last decades. In 2006, Law 1111 unified the consumption tax; by 2010 there was a hike in the consumption tax and its collection was redistributed to health and sport public goods provision. In recent years, by the end of 2016, the tax was increased for the 20-cigarettes pack, which raised its final price by nearly a hundred percent.

The tax hike in 2010 could induce a problem of differentiation of the effect between the non-price related law and the tax increase. However, although both interventions are carried out at the same time, it is unlikely that the tax will vary with the distance of households to commercial activity (as the identification strategy would explain later). However, households could respond to the tax by reducing their tobacco consumption in the formal sector and increasing it in the informal sector. This paper considers the physical exposure of households to tobacco consumption through formal commerce; then, it is not possible to identify the extent to which households are exposed through street vendors. In this sense, the fact that households modify their means of purchase implies that there would be more households that do not comply with the law, and therefore, the reductions in prevalence would be lower. This paper assumes that the pass-through effect could affect the intensive margin but not the extensive. Then, the differential effect of the tax can not be attributed to the spatial exposure of households to tobacco use.

[1] However, and recognizing that this is a comprehensive policy, this paper will refer to it as the smoke-free environment policy.

3 Literature Review

Tobacco consumption is an issue of great public health importance since preventive regulatory actions can have substantial and sustained effects on aggregate smoking and welfare in the long-run (Lewit and Coate, 1982; Douglas, 1998; Kidd and Hopkins, 2004). One can consider that smokers generate negative externalities on society if the utility of a non-smoker agent is directly affected by the action of a smoker, which generates market inefficiencies. The basic source of those inefficiencies is the divergence between social and private benefits. Thus, regulation on tobacco consumption that eliminates or reduces such divergences is required to correct smokers' behavior and maximize social welfare (Hindriks and Myles, 2013). The simplest policy solution to a negative externality is a corrective Pigouvian tax, which is the most used and effective strategy in the fight against tobacco consumption (?). However, other types of regulatory actions, such as clean indoor spaces and advertising bans, that could be classified as command-and-control regulatory measures, are also relevant. 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 (Sebrié et al., 2008).

Some research has focused on the impact of anti-smoking advertising, tobacco price changes, and indoor restrictions, on youth smoking. It has found that an increase in the price of tobacco products discourages teenagers to intensively smoke, due to an income and a substitution effect. Anti-tobacco advertising policies have significant effects on prevalence, and clean indoor policies have had significant impacts on smoking intensity. However, there is little evidence on the effects of these policies on prevalence and initiation (Lewit and Coate, 1982; Czart et al., 2001; Chaloupka and Grossman, 1996), due to relatively weak enforcement of these laws. And there is scarce evidence on the effect of availability of purchase (Czart et al., 2001), and spatial exposure to tobacco use on smoking prevalence.

The policy studied in this document is related to smoke-free environments, advertising bans, and the prohibition of sticks sale. However, the main focus of the regulation is the smoke-free environment component. In this regard, the literature has shown that smoke-free workplaces are associated with reductions in smoking, both at the extensive and intensive margin (Repace and Lowrey, 1980; Chapman et al., 1999; Shopland et al., 2001; Borland et al., 2006). Therefore, smoke-free workplaces not only protect secondhand smokers but also encourage smokers to quit and/or reduce consumption, and it has been argued that indoor restrictions curb smoking through intensity reductions (Goodman et al., 2009). These policies have shown that both non-smokers and smokers benefit from them and are cost-

effective (Sebrié et al., 2008; Gruer et al., 2012). In this sense, 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 such policy. In terms of law enforcement, Bogotá was one of the cities that implemented monitoring plans in sanitary inspections, and it was found that 91% of commercial establishments complied with the law. Further, there is evidence on commerce 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).

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). Furthermore, it has been shown that the availability of purchase within the household has a positive impact on initiation (Lewit et al., 1981). The effect of tobacco consumption exposure on household smoking prevalence is measured in this research, which takes into account the decision making within the household, and may be affected by each of its members. This study uses data on household smoking prevalence, as one could not dig into household members smoking habits.

It is also important to deepen the analysis on how people internalize the de-normalization of smoking. 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 take into account adaptative conduct under prescriptions of appropriate actions and imitation behavior (Krupka and Weber, 2009). In Section 4, these channels will be presented in more detail.

4 Transmission mechanisms: contextualizing the effects

Why and how would the setting presented in this research identify the effect of tobacco use exposure, through proximity to commercial activity, on household smoking prevalence, are still unresolved questions in this document. 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, the mechanism through which household members would change their smoking behavior, due to a smoke-free environment policy, would be analyzed. Unfortunately, with the current data, it is not possible to disentangle these mechanisms.

4.1 Law enforcement in commercial establishments

The direct enforcement of the policy evaluated in this research, which includes clean indoor spaces, the prohibition of stick sales and restrictions on advertising, is challenging to implement. On one hand, commerce spots could not comply with it to avoid losing sales and customers. On the other hand, individuals would be willing not to embrace the norm as it would affect the utility derived from social interaction while consuming cigarettes. The following two subsections analyzes 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, a proper enforce of the law would require to monitor all kind of indoor spaces and commercial spots where cigarettes could be purchased and consumed. In this sense, the implementation and enforcement of the law depends 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 implementation of the policy; they conducted an intense education of the bar owners during the six months before the effective date of the resolution (Uang et al., 2018). In this sense, there is evidence of commerce self-enforcement by business owners. Also, evidence from other countries shows that firms revenues are not affected by complying with this type of norm, while 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 could not buy per stick, could 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 the implementation of 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 or not with the norm. An individual who knows and understands a norm can decide whether to comply or not with it (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 applicable. Agents can update their probability of complying to the norm by obtaining information, coming from the public efforts to discourage smoking and the de-normalization of the habit. In this sense, being near and highly exposed, in terms of commercial density, to tobacco use implies that an individual is more exposed to the fact that smoking in indoor spaces is forbidden and reduces smoking by increasing the probability of compliance with the social norm.

4.2 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 derive utility from lighting up itself, but also 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 decreases would be expected, since smoking, as a whole, generates 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 commerce activity. From the literature on pro-social behavior, one can identify two possible mechanisms through which social norms would 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 exert an influence on 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 that surrounds them. The social value of smoking is reduced, given that it is inappropriate to consume tobacco in public spaces, where social consumption takes place. 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 as well. Then, if an individual is close to commercial zones that have high-density commerce spots, s(he) will be exposed more frequently to compliance with the norm than an individual who is far or less exposed to commercial activity. Therefore, whoever is most exposed to compliance with the law will reduce the probability of being a smoker.

5 Data

This research uses information on household expenditure, socio-demographic characteristics of household heads, and commerce spots in Bogotá. This section will present the construction of the measures that account for the extent to which a household is exposed to tobacco consumption or affected by the policy, and possible issues that could affect our identification strategy later on.

5.1 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 an enterprise develops 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,

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

where darker blue spots indicate a higher accumulation of commerce establishments per square kilometer. The concentration of commerce is on the north-east part of the city, where downtown and workplaces are located. As it is argued that being near a commerce spot influences the degree in which a household is exposed to tobacco use, shaping household smoking behavior, one would want to understand whether there is a positive spatial correlation between distance to commerce and smoking habits. Orange spots in Figure 1 account for smoking prevalence by block, coming from a dataset which will be described in the subsection below, and one can observe that the concentration of smokers is in the same zone as commercial activity, mostly concentrated in the eastern part of the city.

5.2 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 this 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 addresses, I made the following assumptions and calculations.

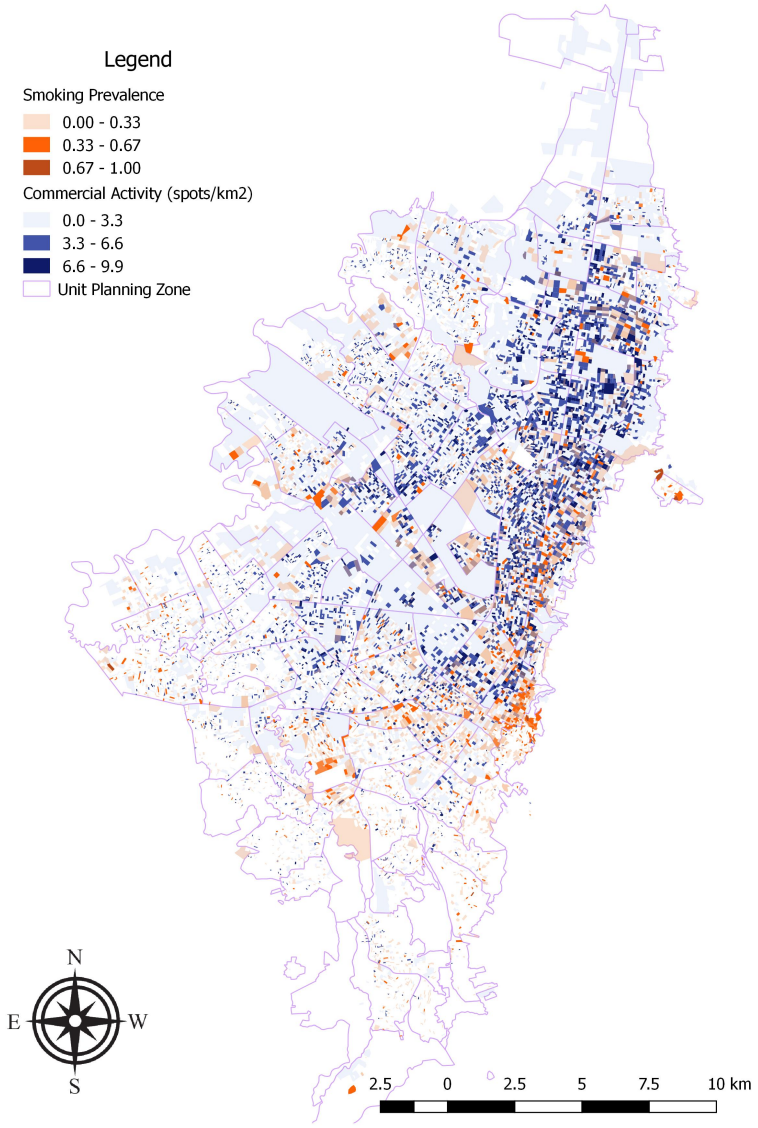
On the one hand, the ECVB-2007 has no information on individual smoking habits, while there is information on monthly tobacco expenditure by household. As it can happen that a household that spends in tobacco products does not consume them, we assume that a household that reports expenditure on tobacco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

This data sets also contain information on demographics at the individual level (age, gender, educational level, household composition) and household location. Figures 2 and 3 show surveyed blocks in both years associated with commercial activity. In Figure 2, one has households that are exposed in a near (red) or distant (blue) extend to commercial activity; while in Figure 3, we have households exposed in a high (purple) or low (green) density to commerce (for further information on the identification strategy see Section 6).

[3]To validate that both years are comparable, prevalence is calculated using the tobacco expenditure assumption for the year 2011 and it is 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 head socio-demographic characteristics to each unit of observation (household). Table 1 presents descriptive statistics by year and intention to be treated (see Section 6 for further details on treatment assignment). Treatment "intention" is assigned using households' exposure to commerce activity since the law affects directly the advertising, promotion and cigarette consumption in public areas to which a household member would be exposed at a near or distant extent. As commercial density will be used to explore exposure intensity heterogeneous effects, descriptive statistics are also presented using 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. Sociodemographic Characteristics								
Age	47.448	47.188	45.665	44.787	48.396***	49.188	46.086	45.712
Gender	0.359	0.373	0.334	0.310	0.379***	0.390**	0.376	0.382
Household Composition								
Ratio Kids/Adults	0.427	0.403	0.641	0.655	0.391***	0.362***	0.570	0.426
Total individuals	3.242	3.135	3.754	3.764	3.165***	3.131**	3.631	3.521
Educational Level								
Primary	0.381	0.336	0.657	0.649	0.218***	0.172***	0.397	0.363
Secondary	0.184	0.178	0.200	0.197	0.357***	0.311***	0.451	0.441
Tertiary	0.435	0.485	0.143	0.154	0.447*	0.539**	0.163	0.206
Commuting								
Commuting time	0.567	0.552	0.735	0.747	0.608***	0.638***	0.703	0.617
Commuted distance	11.770	11.604	14.495	14.784	13.327***	14.294***	14.062	13.076
Income Quintile								
Quintile 1	0.175	0.158	0.258	0.266	0.171	0.136**	0.279	0.201
Quintile 2	0.175	0.154	0.292	0.284	0.170	0.138	0.276	0.247
Quintile 3	0.193	0.182	0.237	0.233	0.190	0.168	0.229	0.222
Quintile 4	0.220	0.235	0.145	0.134	0.229*	0.231***	0.128	0.219
Quintile 5	0.238	0.271	0.069	0.084	0.240	0.327	0.088	0.111
Panel B. Outcome and Treatment Variables								
Distance (nearest)	63.678	50.874	869.502	879.668	62.454	35.715***	853.074	634.956
Commercial Density (nearest)	0.643	5.118	0.510	5.245	0.519***	5.661	0.238	5.243
Prevalence	0.196	0.192	0.203	0.234	0.179***	0.165***	0.196	0.160
Observations	2,172	4,947	6,816	12,136	288	4,735	1,241	9,993

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 commerce block is lower than the average distance (60 meters approximately), it is classified as being Far otherwise. 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 commerce spot in its surroundings, and it is measured in meters, while commerce density is measured as the number of commerce 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 (HH) living far from commerce activity are younger than their counterparts, with HH aged 47.4 and 48.5 years old in 2007 and 2011 for the households that are located near commerce spots, respectively; and 45.4 (2007) and 46.1 (2011), for households located far from commerce spots. A higher proportion of women HH is found near commerce spots (36% in 2007) than 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 different within treatment assignment. On education, there are vast differences between near and far households for 2007 and 2011, moving towards intermediate educational levels. There are no significant differences in terms of 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, therefore exposed to a different extent to tobacco use. 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). Additionaly, household members that live near to commerce spots tend to take less time to reach their places of work and/or 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 noisy since it is a construction using the average speed of means of transport (CAF, 2010).

As shown in Panel B of Table 1, the average distance to commerce spots for households located near commerce is of around 60 meters (less than a block), while for the households that are far, 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.

Given the differences presented above (Table 1), household characteristics are fixed over time using a matching strategy. With this empirical strategy, one guarantees that the structure of households in 2011 that are near to commercial activity is compared with similar households that are far in 2011, and near or far in 2007.

Limitations

The main problem of the origin of this information is that it is not possible to identify whether the commerce spots were founded before 2009, when the policy came into force, since information is only available in 2016. 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 twentieth 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 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 entered in place (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.

6 Empirical Strategy

This paper uses commerce spots to measure the intensity in which a household is exposed to tobacco use. For that purpose, one constructs two measures of exposure, which complement each other. As the information on household block location is available, measures are constructed at the block level. First, I obtain the household's nearest commerce block[4] and measure the distance in meters from the household to commerce block. Although households decide where to live, and may take commercial activity into account in their decision making, the policy induces exogenous variation in households' exposure to tobacco use and advertising. Furthermore, as the policy is implemented at the country level, the probability of changing the location due to the policy implementation is very little.[5]

In this sense, distance accounts for the measure in which a household is intended to be treated and induces variation on the extent to which an individual is able to purchase and consume cigarettes near his home, i.e., the magnitude in which a household is exposed to tobacco use. Second, not only the distance but the density of the commercial activity that surrounds a household might influence the decision to smoke, i.e., being near and with greater density of commerce makes a household more exposed to tobacco use, and therefore influence its members smoking decisions. Thus, the commercial density of the nearest commerce block matched in the first definition of smoking exposure is assigned to

[4]Block that contains at least one commercial establishment.

[5]The effect of the law on house prices can be ambiguous. On the one hand, the policy can improve air quality in an area with high commercial density, which increases the value of housing and reduces the budget available for tobacco consumption. On the other hand, the law affects consumption in public spaces, then there may be a substitution effect between public smoking and tobacco use inside the household, which might reduce the rent. There is little evidence on the effects of a public policy of smoke-free environments on the price of housing. However, anecdotal evidence of private policies of smoke-free spaces within residential complexes shows that property values are negatively affected by this type of intervention.

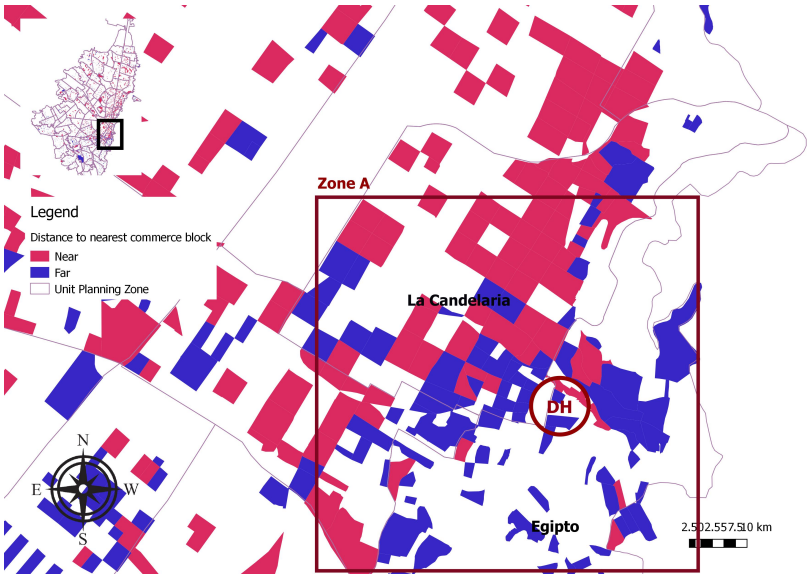
the observation, to account for a second exogenous source variation on tobacco exposure intensity.[6]

Figure 2 shows that there is variation in households' distance to commerce spots within small geographical zones, derived from the fact that being near implies that households are at 60 meters from the commercial activity on average. On top of the map presented in Figure 2, there is a sector of the city center known as La Candelaria and Los Mártires. This area groups a large part of the city's commercial activity. Therefore households located in this sector have a higher probability of being near commerce establishments; the bottom right of the figure corresponds to a residential neighborhood (Egipto), where it makes sense that commercial activity is far from households. Figure 3 shows that there is a correlation between being near and being exposed in a higher intensity (density), since the sector of La Candelaria and Los Mártires are highly dense, while Egipto is exposed in a smaller extent.

Furthermore, there is variation in both measures in a small geographical area. Let us take Egipto as an example; as shown in Figure 2, commercial activity is located far from households, nevertheless, from Figure 3 one can observe that households are exposed at a high and low density within the neighborhood. Let us take as an example the zone denoted with DH in Figures 2 and 3. DH corresponds to the area of the neighborhood that is closest to its marketplace. Households are far from this spot but highly exposed, since it concentrates much of the commercial activity in the area. As the definition of closeness and density are arbitrary, the main estimates under several definitions will be explored later (Section 7.2).

[6]Commercial density is measured as the number of commerce spots in a block over the area of the block in kilometers.

Figure 2: **Distance**



Source: ECVB 2007, EMB 2011, Directorio Nacional de Empresas (DANE). OpenStreet Map. Author's calculations.
Note: To the north area (upper part of the figure) there is a sector of the city center known as La Candelaria and Los Mártires. This sector groups a large part of the city's commercial activity. Therefore households located in this sector have a greater probability of being near commerce establishments; the bottom right of the figure corresponds to a residential neighborhood, called Egipto, where it makes sense that commercial activity is far from households. DH corresponds to the area of the neighborhood that is closest to the Egipto's marketplace

Figure 3: **Density**

Source: ECVB 2007, EMB 2011, Directorio Nacional de Empresas (DANE). OpenStreet Map. Author's calculations.
Note: There is a positive correlation between being near and being exposed in a greater intensity (density), since the sector of La Candelaria and Los Mártires are highly dense, while Egipto is exposed in a less extent.

6.1 Matching technique

To assess variations which are representative for similar households, and taking into account that only two waves of information are available, such that one could not test the common trend assumption, a Propensity Score Matching technique is performed. It selects and weights households before and after the intervention and by its distance to commerce blocks (near and far), to make them comparable. It is assumed that being assigned to treatment is explained by age, gender, education level, household composition, and commuting characteristics, given that a member of a household does not uniquely stay near their place of living. Instead, they go out to work or study in different places in the city (For further details go to Appendix A).[7] After that, a Difference-in-Differences model after a matching strategy (matched-DiD) is estimated, following Blundell and Dias (2009).

After matching, all variables are 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 less household members in 2011.

6.2 Difference in Differences

To 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, we first need to define the treatment assignment. For this, households' exposure to commercial activity is going to be used, since the law affects directly the advertising, promotion and cigarette consumption in public areas to which a household member would be exposed at a near or distant extent. In this sense, exposure to commerce is defined by the distance of a household to the nearest commercial spot within a block (in a neighborhood) or the blocks in its vicinity. A household is near ($Dist_b^n = 1$) if the distance of the household to its nearest commerce block is lower than the average distance of households to commercial activity, which could have a low or a high density. Thus, a household is assigned to treatment if the distance is lower than its average (Figure 2 presents an example). Having defined this, to explore the impact of the smoke-free environment policy on smoking prevalence at the

[7] To obtain the best fit between each pair of individuals, this paper implements a Kernel Propensity Score Matching with common support grouping by borough (*Localidad*) and treatment (near vs. far). To measure the distance between the two vectors of covariates, without imposing a maximum distance, it uses the household head (hh) age, gender and educational level, the ratio kids over adults, the imputed commuting distance and time, and the income quintile

household level, we use a Difference-in-Differences strategy, stating the following:

Table 2: Sample Balance - Matching by Borough

	Mean							
	2007				2011			
	Near		Far		Near		Far	
Variable	Low	High	Low	High	Low	High	Low	High
Panel A. Sociodemographic Characteristics								
Age	46.743	46.413	44.897	44.156	47.622	48.926	45.021	46.414
Gender	0.339	0.355	0.320	0.291	0.345	0.360	0.350	0.360
Household Composition								
Ratio Kids/Adults	0.469	0.466	0.683	0.673	0.426	0.370	0.601	0.433
Total individuals	3.432	3.376	3.917	3.879	3.287	3.265	3.685	3.629*
Educational Level								
Primary	0.405	0.369	0.658	0.644	0.212	0.176	0.391	0.409
Secondary	0.196	0.198	0.224	0.198	0.364	0.305	0.464	0.436
Tertiary	0.399	0.433	0.118	0.158	0.442	0.538	0.155	0.173
Commuting								
Commuting time	0.620	0.611	0.765	0.763	0.665	0.683	0.720	0.638
Commuted distance	13.086	13.053	15.241	15.190	14.811	15.544	14.516	13.561
Income Quintile								
Quintile 1	0.157	0.142	0.245	0.248	0.148	0.115	0.268	0.201
Quintile 2	0.181	0.169	0.304	0.286	0.167	0.129	0.279	0.245
Quintile 3	0.207	0.209	0.250	0.243	0.206	0.181	0.236	0.238
Quintile 4	0.226	0.234	0.135	0.135	0.232	0.251	0.130	0.228
Quintile 5	0.228	0.247	0.068	0.088	0.247	0.324	0.087	0.088
Panel B. Outcome and Treatment Variables								
Distance (nearest)	63.678	50.874	869.502	879.668	62.454	35.715	853.074	634.956
Commercial Density (nearest)	0.629	5.115	0.538	5.256	0.637	5.669	0.376	5.599*
Prevalence	0.187	0.185	0.193	0.224	0.168	0.167	0.190	0.168
Observations	2,172	4,947	6,816	12,136	288	4,735	1,241	9,993

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 commerce 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 commerce spot in its surroundings, and it is measured in meters, while commerce density is measured as the number of commerce 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.

$$y_{hbpt} = \delta_1 Dist_b^p + \delta_2 Post_t + \theta \left(Dist_b^p \cdot Post_t \right) + \beta' X_h + \eta_p + \upsilon_{hbpt} \tag{1}$$

where y_{hbpt} is the smoking prevalence of household h, located in block b, urban planning zone (UPZ) p at time t; η_p are UPZ fixed effects to account for UPZ observable and unobservable characteristics that do not change over time. 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 UPZ level (υ_{hbpt}). The parameter of interest under this specification is θ which shows the causal effect of being near a commerce spot, after the implementation of the law, on household smoking behavior.

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

7 Results

If the policy were effective, one would expect to find that there are reductions in household smoking prevalence. People who are close to commerce blocks would be less spatially exposed to tobacco consumption and experiencing 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. They are presented as follows. First, the effect of being near or far on the household smoking prevalence after the implementation of the policy, will be explored using the Difference-in-Differences 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., is closer than 60 meters which is the average distance in the whole sample. 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 Difference-in-Differences model, one would like to observe what would have happened if we do not take into account

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 to commercial activity, it is more likely 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.

Table 3: Difference in Differences Results - Distance (Dichotomous)

	(1) Prevalence	(2) Prevalence	(3) Prevalence	(4) Prevalence
Dist	0.0143**	0.00295	0.00845	0.00253
	(0.00649)	(0.0114)	(0.0116)	(0.0115)
Post	-0.0215***	-0.0209***	0.181***	0.140***
	(0.00525)	(0.00743)	(0.0195)	(0.0253)
DistXPost	0.00560	0.000143	-0.00704	-0.000389
	(0.00973)	(0.0152)	(0.0154)	(0.0153)
Dep. Mean	0.1978	0.1986	0.1986	0.1986
Dep. SD	0.3984	0.3989	0.3989	0.3989
Observations	33109	32643	32643	32643
Blocks	4137	4081	4081	4081
UPZ	100	100	100	100
Matching weights	No	Yes	Yes	Yes
Robust errors	Yes	No	No	No
UPZ FE	No	Yes	Yes	Yes
Controls	No	Yes	No	Yes
Inter. Controls	No	No	Yes	Yes

Clustered standard errors in parentheses

* $p < .1$, ** $p < .05$, *** $p < .01$

Note: Being close to a commerce spot after the implementation of the smoke-free policy reduces prevalence in, at most, 0.7 percentage points.

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 is a decreasing trend in smoking prevalence over time. Being near commerce spots after the intervention, which implies that one should be exposed to less consumption, given that smoking is forbidden in indoor spaces, has a non-significant increase in smoking prevalence that is not different from zero (0.014 pp.). When controlling for trends in the control variables, the trend in smoking prevalence is reversed and the effect, while still non-statistically different from zero, becomes negative. Column (4) presents a complete specification, in which

controls are introduced in levels and interacted over time to account for tendencies in all observable socio-demographic characteristics. As before, being near a commerce spot after the implementation of the law, has a non-significant reduction of 0.03 pp. in household smoking prevalence, i.e., household prevalence does not vary as a result of the implementation of the law. This results consider distance as the only source of variation that explains how being exposed to tobacco usage affects the household smoking dynamics at the extensive margin.

7.1 Heterogeneous Effects

Exposure Intensity

As seen in Figures 2 and 3, households are exposed to the implementation of the law both by distance and density. Distance accounts for the extent to which a household is exposed. However, the intensity in which a household is exposed to tobacco use is determined by commercial density. The density of commerce blocks is defined as the ratio between the number of establishments in a block over its area. In this sense, 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 uses a Triple-Difference specification as follows:

$$\begin{aligned} y_{hbpt} = \delta_1 Dist_b^p + \delta_2 Post_t + \delta_3 Dens_b^p \\ +\gamma_1 \left(Dist_b^p \cdot Post_t\right) + \gamma_2 \left(Dist_b^p \cdot Dens_b^p\right) + \gamma_3 \left(Post_t \cdot Dens_b^p\right) \\ +\theta \left(Dist_b^p \cdot Post_t \cdot Dens_b^p\right) + \beta' X_h + \eta_p + \xi_{hbpt} \end{aligned} \tag{2}$$

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 commerce 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 $\hat{\gamma}_1$.

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 commerce blocks, compared to households that are near to commercial places with low density in 8.5 pp. independently of the specification, since being spatially and socially exposed to cigarette use in 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 - Density (Dichotomous)

	(1) Prevalence	(2) Prevalence	(3) Prevalence	(4) Prevalence
Dist	0.00479	-0.00686	-0.00307	-0.00858
	(0.00777)	(0.0119)	(0.0115)	(0.0113)
Post	-0.0193***	-0.0200**	0.182***	0.142***
	(0.00601)	(0.00905)	(0.0203)	(0.0251)
Dens	0.000584	-0.00174	-0.00140	-0.00147
	(0.00707)	(0.00872)	(0.00907)	(0.00880)
DistXDensXPost	-0.0649**	-0.0649	-0.0719*	-0.0716*
	(0.0301)	(0.0396)	(0.0396)	(0.0394)
DensXDist	0.0314**	0.0331*	0.0386**	0.0374*
	(0.0142)	(0.0191)	(0.0194)	(0.0194)
DistXPost	0.0161	0.0122	0.00676	0.0131
	(0.0108)	(0.0152)	(0.0150)	(0.0147)
DensXPost	-0.0188	-0.00658	-0.00456	-0.00493
	(0.0143)	(0.0132)	(0.0132)	(0.0133)
Dep. Mean	0.1978	0.1986	0.1986	0.1986
Dep. SD	0.3984	0.3989	0.3989	0.3989
Observations	33109	32643	32643	32643
Blocks	4137	4081	4081	4081
UPZ	100	100	100	100
Matching weights	No	Yes	Yes	Yes
Robust errors	Yes	No	No	No
UPZ FE	No	Yes	Yes	Yes
Controls	No	Yes	No	Yes
Inter. Controls	No	No	Yes	Yes

Clustered standard errors in parentheses

* $p < .1$, ** $p < .05$, *** $p < .01$

Note: Being close to a commerce spot, which density is high, after the implementation of the smoke-free policy reduces prevalence in, at most, 7.19 percentage points. Compared to close commerce spots with low density, reductions are close to 8.5 pp.

Socio-demographic Characteristics

To deepen the analysis in 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 household head are set.

Table 5 presents the estimation of the most complete specification of the model, i.e. column (4) of table 3, including heterogeneous effects as described above. Columns (1) and (2) present the results by age group, defining young as household heads younger than 45 years old and old otherwise. It has been shown that longer habit duration makes the cessation processes more difficult (Douglas, 1998; Becker and Murphy, 1988) 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 (whose household head is older) are less sensitive to the policy. Therefore, younger people would be more responsive to a smoke-free environment intervention. There is evidence of a reduction in smoking prevalence for households whose head is classified as young, compared to old household heads, of around 11.6 pp., due to a lower tobacco use exposure, both by being near and intensively exposed to commercial activity.

Columns (3) and (4) of Table 5 show the estimation by household composition in terms of children, defining Kids if there is a child or more living in the household, and No Kids in any other case. The evidence on the relationship between parents' smoking behavior and their household composition is scarce and inconclusive. There is evidence on tobacco use reductions in pregnant women (Lumley et al., 2009; Kendrick et al., 1995; ?), 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, both 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 non-significant net reduction of 4.1 pp in household smoking prevalence when there is at least one child (-8.9 pp) compared to families with no kids (-4.70 pp). Estimations changing the definition of $Kids$ (defining the variable with one more child, i.e., $Kids = 1$ if there were two kids or more) lead to the same results.

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

Table 5: Difference in Differences Results - Heterogeneous Effects

	Age Group		Kids at home		Occupation	
	Young	Old	No Kids	Kids	Unskilled	Skilled
	(1)	(2)	(3)	(4)	(5)	(6)
Dist	-0.00828	-0.00557	-0.0303	0.00509	0.00415	-0.0152
	(0.0139)	(0.0160)	(0.0227)	(0.0114)	(0.0225)	(0.0110)
Post	0.132***	0.170***	0.141***	0.143***	0.0345	0.163***
	(0.0394)	(0.0537)	(0.0295)	(0.0388)	(0.0433)	(0.0302)
DistXPost	-0.00191	0.0355*	0.0424	-0.00361	0.0185	0.0116
	(0.0179)	(0.0192)	(0.0267)	(0.0172)	(0.0260)	(0.0149)
DensXDist	0.0477**	0.0132	0.0370	0.0378	-0.0115	0.0629**
	(0.0232)	(0.0260)	(0.0387)	(0.0283)	(0.0262)	(0.0282)
DistXDensXPost	-0.113**	0.00380	-0.0470	-0.0888*	0.0157	-0.108**
	(0.0502)	(0.0494)	(0.0640)	(0.0529)	(0.0553)	(0.0526)
Dep. Mean	0.2102	0.1784	0.1984	0.1987	0.2062	0.1942
Dep. SD	0.4074	0.3828	0.3988	0.3991	0.4046	0.3956
Observations	20763	11880	12694	19949	11805	20838
Blocks	2557	1529	1674	2413	1493	2591
UPZ	100	100	100	100	100	100
Matching weights	Yes	Yes	Yes	Yes	Yes	Yes
UPZ FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Inter. Controls	Yes	Yes	Yes	Yes	Yes	Yes

Clustered standard errors in parentheses

* $p < .1$, ** $p < .05$, *** $p < .01$

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. Being close to a highly dense commerce spot after the implementation of the smoke-free policy, compared to a lowly dense commerce block, reduces prevalence in 11.6 pp more for young household heads than old ones; 4.1 pp for households with kids compared to households with no kids, and 12.4 pp more for skilled household heads compared to their unskilled counterparts.

simultaneously; an individual is classified as skilled if s(he) is occupied, has a higher educational level than secondary and her(is) occupation is one of the following: government worker, self-employed or boss. 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 they are more affected by the law. Skilled workers reduce their smoking prevalence more than unskilled household heads, in around 12.4 pp.

7.2 Robustness checks

Several robustness checks regarding the definition of treatment are conducted. Initially, all observations at the block level that were repeated within waves are kept to construct a panel at this observational level, and estimations are run. Then observations were assigned to treatment if the distance between the household and the commerce block was in the 25th percentile of the distance distribution, and to the control group if the distance was in the 75th percentile, dropping all remaining observations. Then a sensitivity analysis of the definition of treated units in the dichotomous version of the analysis is made, changing the distance threshold. Finally, a placebo test is conducted using the second specification.

Panel of blocks

In this research, we have constructed a repeated cross-section database, which was balanced in all observable characteristics using a propensity score matching technique, in order to make proper inference about these data. In this subsection, a panel data set at the block level is constructed, since there are blocks that were surveyed in both waves.[8] However, it should be viewed with caution since the probability that a block is chosen randomly more than once to be surveyed is low. Column (1) of Table 6 shows that block smoking prevalence has not been reduced significantly for blocks that are close to commerce activity after the implementation of the law. When taking density into account (Column (2) of Table 6), the effect present in the initial specification vanishes, and there is a non-statistically significant increase in the prevalence of around 5.4 pp.

25th percentile vs. 75th percentile of distance distribution

Initially, we defined treatment assignment for the dichotomous version of the model using the average of inverse distance and density. A household was assigned to treatment (near) if the inverse distance to nearest commerce block is higher than the average inverse distance, and was intensively affected by commerce (high density) if the there were more commerce spots in the nearest commerce block than the average density. In this subsection, observations that are exposed to an extreme extent to commerce (very close or very far) would be compared,

[8]The sampling unit in these surveys is the segment, which corresponds to a set of real estate located within the same block or nearby blocks. All the households and people that make up each segment are surveyed. Moreover, each sampling unit has a known probability of inclusion greater than zero; therefore, the likelihood that a block is chosen randomly more than once is low (DANE, 2014).

not taking density into account. On the one hand, one would have households that are very close to commerce, that in fact, may have commerce in the same block (percentile 25th of the distance distribution). On the other hand, households that are very far away from commercial activity (percentile 75th of the distance distribution) are taken into account.

Column (3) of Table 6 shows that although non-significant, being near a commerce spot after the implementation of the law implies a reduction of 2.12 pp. in household smoking prevalence.

Table 6: Difference in Differences Results - Robustness

	(1)	(2)	(3)
	Block Panel		25th vs. 75th
	First specif.	Second specif.	First specif.
Dist	0.0279	0.0247	0.0333**
	(0.0263)	(0.0263)	(0.0136)
Post	0.355**	0.399***	0.130**
	(0.160)	(0.143)	(0.0616)
DistXPost	-0.00624	-0.00803	-0.0212
	(0.0346)	(0.0345)	(0.0465)
DistXDensXPost		0.0545	
		(0.0635)	
Dep. Mean	0.1895	0.1895	0.2021
Dep. SD	0.1501	0.1501	0.4016
Observations	952	952	17151
Matching weights	Yes	Yes	Yes
Robust errors	No	No	No
UPZ FE	Yes	Yes	Yes
Controls	Yes	Yes	Yes
Inter. Controls	Yes	Yes	Yes

Clustered errors in parentheses

* $p < .1$, ** $p < .05$, *** $p < .01$

Note: Using a panel structure, being close to a commerce spot after the implementation of the smoke-free policy reduces prevalence in, at most, 1.24 percentage points and being close to a commerce spot, which commercial density is high, after the implementation of the policy increases smoking prevalence in 3 to 5 percentage points. In a repeated cross-section, using observations with distance to commerce blocks lower than the 25th percentile against the ones greater than the 75th percentile, being close to a commerce spot after the implementation of the smoke-free policy reduces prevalence in 2.12 percentage points.

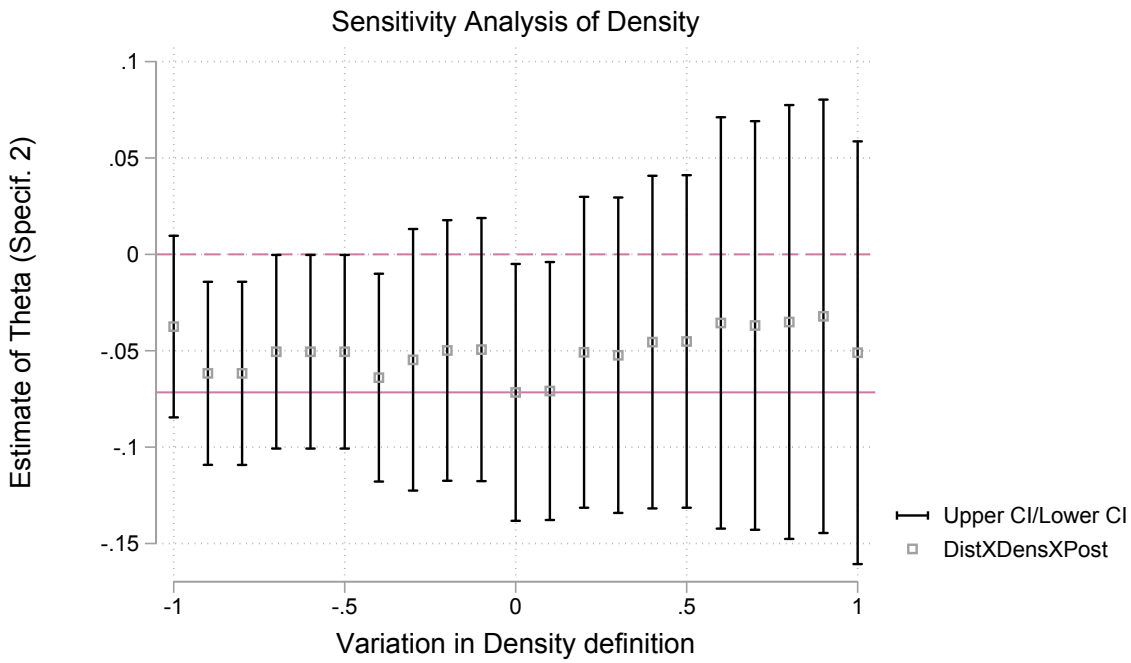
Sensitivity analysis

As in the previous subsection, we address the issue of defining the threshold that classifies observations into the treated and control groups ad hoc, by doing a sensitivity analysis.

Figure 4 presents the estimated effect of being near a highly dense commerce 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 average density as before 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 normalize 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 to low density commercial blocks, being statistically significant in some cases, when we define the threshold as a lower value than the average of the city's density. However, it is clear that the significance of the effect disappears when the threshold is set over the average of density, which happens because the number of observations available is reduced increasing the standard error; the opposite happens to the left. However, the estimated coefficient is stable.

Figure 4: Sensitivity Analysis - Density



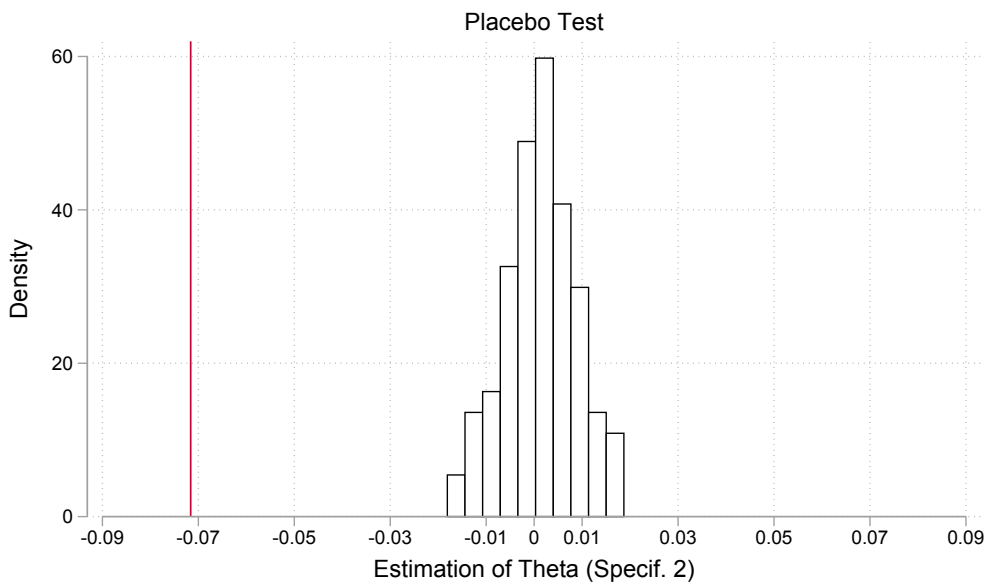
Note: Density is defined using the average density as before plus an arbitrary value between -1 and 1, with breaks of 0.1. For graphical representation, we normalize the cutoff to zero when using the average density.
Source: Author's calculations.

Placebo test

Finally, a placebo test is performed to verify that the use of distance as the variable for treatment assignment does not lead the results. It is conducted in two ways. The first one consist of randomly assigning values to the high and low-density dummy, by drawing artificial density values from a uniform distribution between zero and five.[9] 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 the average distance of households to its closest commercial block. Instead, in this exercise, distance is randomly allocated from a uniform distribution, between 0 and 800 meters.[10]

Both procedures are executed a hundred times, and the following histograms 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 is robust to the definition of distance and density used before to identify whether households are exposed to the policy and intended to be treated.

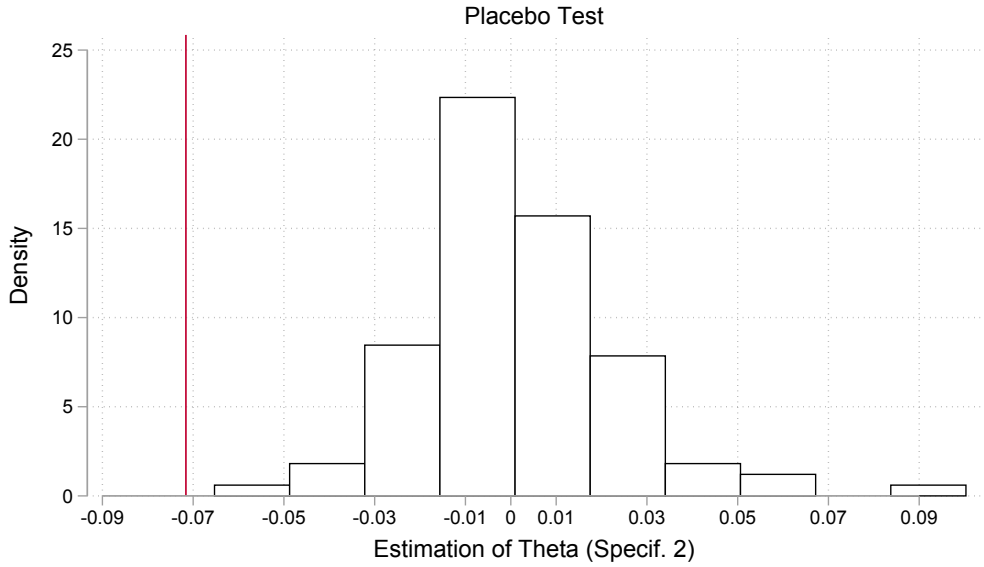
Figure 5: Placebo test - Distance



Note: Artificial density values from a uniform distribution between zero and five are set, while the distance variable is not modified. This procedure is executed a hundred times.
Source: Author's calculations.

[9]Five is the average continuous density measure of the high-density category.
[10]800 is the average continuous distance measure of the far category.

Figure 6: Placebo test - Distance + Density



Note: Both distance and density are randomly set as dummies. Distance takes values from a uniform distribution, between 0 and 800 meters. It also draws artificial density values from a uniform distribution between zero and five. This procedure is executed a hundred times.
Source: Author's calculations.

8 Discussion and conclusions

This research estimates the effect of a smoke-free environment tobacco control policy on the household smoking behavior in Bogotá, a big city in a middle-income country. It takes into account the spatial exposure of households to tobacco use, by exploiting a Difference-in-Differences strategy and exploring exposure intensity heterogeneous effects. It also presents and discusses diverse transmission mechanisms through which distance and density may affect household smoking behavior. It is found that there is a decrease in household smoking prevalence, of 8.5 percentage points on average (which is robust to the treatment assignment rule) when the commercial density is assumed to be affecting the consumption decisions of household members. That is, households that are near to highly dense commerce blocks reduce their smoking prevalence more than households near to lowly dense commerce blocks in around 8.5 pp., which is a big reduction from an smoking prevalence of 19.2% in 2007. As the law reduces the usage of tobacco at 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. Accordingly, this paper finds a smoking prevalence reduction, of 11.6 percentage points on average, for households whose head is classified as young, compared to old household heads. 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 externality 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 non-statistically significant evidence of household smoking prevalence reductions, of 4.2 percentage points on average, when there is at least one child at home compared to households with no kids. Finally, 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, it is found that skilled household heads, who have higher educational and occupational levels, reduce their smoking prevalence more than their unskilled household pairs, in around 12.4 percentage points, as their probability of purchasing cigarettes at the legal commerce sector is higher.

However, Colombia exhibits a large informal commercial activity that may countered 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 household's cigarette consumption dynamics, given that its enforcement in the informal sector is low. Thus, the purchase and consumption of tobacco 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.

This study performs a Propensity Score Matching technique, before implementing a Difference-in-Differences specification, to assess variations which are representative for

similar households, since two waves of information are available and the common trend assumption could not be tested. The main identification assumption when performing this procedure is that there is balance between the treated and control units in unobservable characteristics. However, as informality is an unobserved characteristic, the assumption above would not prevail, and balance could not be guaranteed.

Considering its importance, further research that includes the informal sector could estimate the effect of this policy more precisely. However, this study is an initial approach to understand the effects of non-Pigouvian tobacco control policies in Colombia, and it identifies a lower bound estimation for this type of intervention.

Finally, Colombia has responded to international conventions undertaking several policies to curb tobacco consumption. There has been a comprehensive policy that ratifies the permanent effort to reduce tobacco consumption. In addition to the policy of smoke-free environments, the government of Colombia has implemented tax measures to reduce tobacco consumption in recent years. Although the policy of smoke-free environments seems to be an effective policy in reducing prevalence, even considering the difficulties in enforcing Law 1335 in the informal sector, the literature has shown that excise taxes are the most effective measure to control the tobacco epidemic. In this regard, smoke-free environment policies and tax interventions should go side by side to achieve public health objectives.

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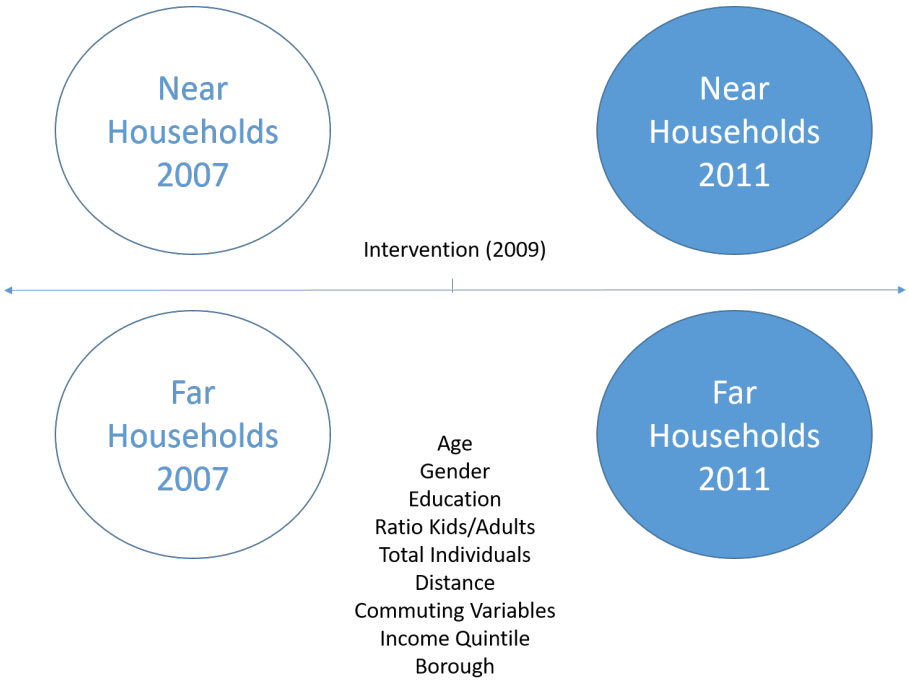
Appendix

A Propensity Score Matching (PSM)

An important concern of comparing households that are near and far 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,d) against the reference (a).

The differences present 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,d). For this, households of groups (b,c,d) are weighted in such a way that their average resembles group (a) average for each of the following characteristics: household head (hh) age, gender and educational level, the ratio kids over adults, the imputed commuting distance and time, and the income quintile (Shown in Figure 7). Considering that two households from different geographical areas, let us imagine east and west, may resemble on observable characteristics but might not be comparable given their location, this paper pre-processes the data using a PSM technique grouping by borough (*Localidad*).

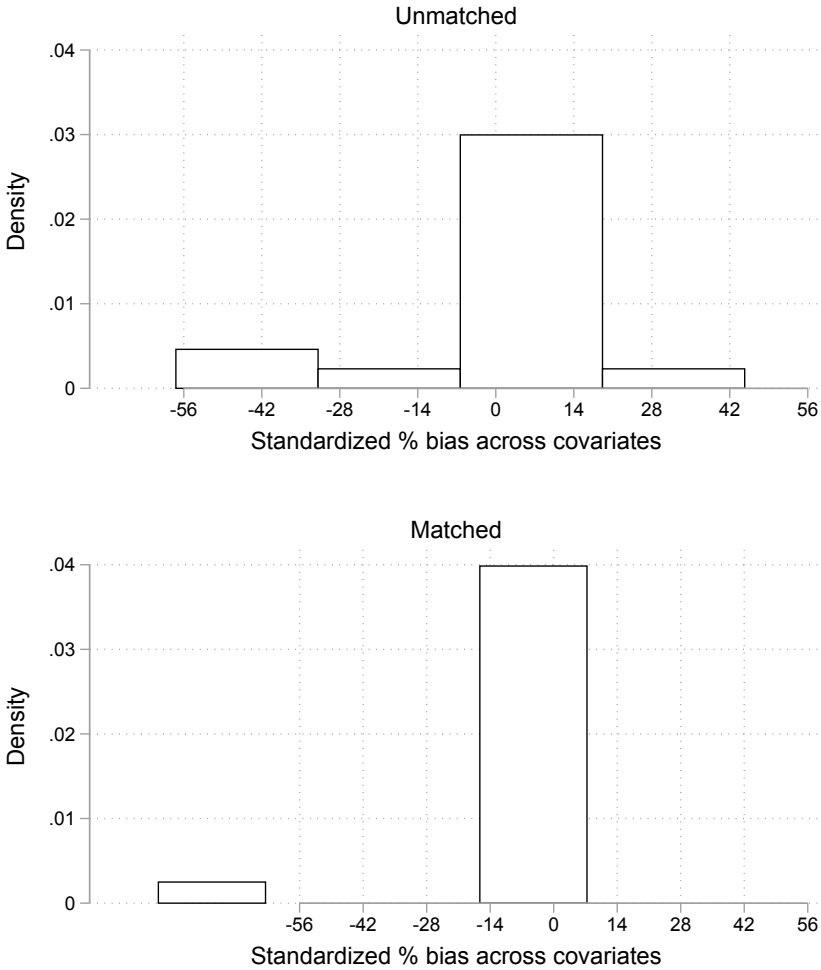
Figure 7: Matching Mechanism



This is based on first estimating a propensity score which indicates the predicted probability that an observation is part of group group (a) rather than the specific comparison group. Then the weights are selected in such a way that the kernel density of groups (a) and its comparison are the same. To obtain the best fit between each pair of individuals, this paper implements a Kernel Propensity Score Matching with common support.

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. As shown in Table 2, Total Individuals and Commercial density present a variance ratio between 0.5 and 0.8, which indicates a poor fit. All other variables have a good fit (Figure 8).

Figure 8: Matching Histogram of % of bias



B Additional Results

Table 7: Difference in Differences Results - Continuous version

	(1) Prevalence	(2) Prevalence	(3) Prevalence	(4) Prevalence
Panel A. First Specification				
Dist	-0.00978***	-0.00223	-0.00547	-0.00553
	(0.00290)	(0.00568)	(0.00567)	(0.00477)
Post	-0.0198***	-0.0213***	0.179***	0.133***
	(0.00442)	(0.00807)	(0.0200)	(0.0228)
DistXPost	0.000497	0.00191	0.00576	0.00618
	(0.00442)	(0.00714)	(0.00734)	(0.00686)
Panel B. Second Specification				
Dist	-0.00886***	-0.00158	-0.00471	-0.00154
	(0.00295)	(0.00550)	(0.00540)	(0.00559)
Post	-0.0236***	-0.0216***	0.179***	0.140***
	(0.00477)	(0.00808)	(0.0201)	(0.0251)
Dens	0.00348	0.00579	0.00689	0.00653
	(0.00274)	(0.00450)	(0.00452)	(0.00443)
DistXDensXPost	0.00753	0.00801	0.00904	0.00900
	(0.00535)	(0.00636)	(0.00628)	(0.00621)
DensXDist	-0.00633**	-0.00619	-0.00675	-0.00649
	(0.00274)	(0.00433)	(0.00426)	(0.00414)
DistXPost	0.00147	0.00206	0.00596	0.00286
	(0.00477)	(0.00717)	(0.00725)	(0.00748)
DensXPost	-0.0148***	-0.0125**	-0.0129**	-0.0128**
	(0.00532)	(0.00624)	(0.00622)	(0.00616)
Dep. Mean	0.1978	0.1986	0.1986	0.1986
Dep. SD	0.3984	0.3989	0.3989	0.3989
Observations	33109	32643	32643	32884
Matching weights	No	Yes	Yes	Yes
Robust errors	Yes	No	No	No
UPZ FE	No	Yes	Yes	Yes
Controls	No	Yes	No	Yes
Inter. Controls	No	No	Yes	Yes

Clustered errors in parentheses

* $p < .1$, ** $p < .05$, *** $p < .01$

Note: Being a one standard deviation, in distance, closer to a commerce spot increases prevalence in, at most, 0.005 standard deviations. Being a one standard deviation closer and to a commerce spot which has a one SD higher concentration of establishments increases household smoking prevalence between 0.007 and 0.009 standard deviations.

Considering that distance and density are continuous, I proceed to understand whether being a meter closer to commercial activity has an impact on smoking prevalence. Panel A of Table 7 shows the results for this specification. As stated above, there is a decreasing trend in smoking prevalence over time, while being a meter closer to a commerce block after the intervention has a non-significant effect on prevalence, such that the increase in smoking prevalence is not different from zero. One can also consider density in a continuous way, such that being closer to a highly dense commerce block would decrease smoking more due to the policy implementation. However, in Panel B of Table 7 the effect present in the dichotomous specification vanishes and there is a non-statistically significant increase in the prevalence of around 0.6 pp.