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OPTIMALITY AND DISTORTIONARY LOBBYING: REGULATING TOBACCO CONSUMPTION [*]

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ABSTRACT: We examine policies directed at regulating tobacco consumption through three types of instruments: (i) an excise tax hindering consumption by increasing the price of cigarettes, (ii) prevention programs helping consumers to make choices that are more time consistent when trading-off the current pleasure from smoking and its future health harms, and (iii) smoking bans directly restricting consumption. First, on normative grounds, we focus on the optimal design of public policies maximizing the economy's surplus. Second, in a positive perspective, we investigate how the lobbying activities of the tobacco industry, of smokers, and of anti-tobacco organizations may distort government intervention.

MAIN RESULT: Excise taxation efficiently targets the behavior of the "average" smoker. Prevention programs improve efficiency when health harms are different across smokers. Smoking bans complement taxation to curb smoking-related externalities. Tobacco producers lobby for lower taxation while citizens lobby on all instruments.

JEL Codes: I18, H23, D72

Keywords: Harmful consumption, Corrective taxation, Lobbying in common agency games

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1 Introduction

Tobacco consumption is exposed to various forms of regulation in many countries. Historically, taxation is the first instrument used by governments, initially mainly as a revenue-raising device, subsequently also as a mean to limit tobacco consumption.[1] While still widely employed, during the last decades an expanded array of instruments — such as smoke-free-air laws, information-campaign programs about smoke-related diseases, bans on advertising, restrictions of youth access to tobacco products — have gained importance complementing taxation as tobacco control policies. Indeed, the empirical evidence on the U.S.A. reported in Section 2 shows that prevention programs, as well as smoking restriction laws, are used jointly with taxation and play an important role, both quantitatively and qualitatively. However, while the theoretical underpinnings of tobacco taxation have a long history that we briefly review in Section 2, those of other types of control policies are still limited.[2] The first purpose of this paper is to investigate how non-price regulatory instruments add to and interact with taxation in the design of tobacco control policies.

Another important factor in tobacco control policies is the role played by special interest groups. Again, although the evidence reported in Section 2 for the U.S.A. shows that powerful lobby groups are active in attempting to lean tobacco control policies towards their goals, the theoretical literature has paid no attention to this issue.[3] To fill this gap is the second purpose of this paper.

We develop a framework in which a policy maker can use three types of regulatory instruments: (i) an *excise tax* that discourages tobacco consumption by increasing its price, (ii) *prevention programs* that affect consumption by inducing smokers to take decisions that are more time consistent when comparing the pleasure of current tobacco

[1] For instance, in the UK, excise duty on tobacco was first introduced in 1660 (Report on tobacco taxation in the United Kingdom, WHO). In the U.S., the first federal excise tax on tobacco products was introduced in 1862, while the first state tax was introduced in Iowa in 1921 (Tax Foundation). The Australian government has imposed an excise tax on tobacco products since 1901 (Australian Government, The Department of Health).

[2] A notable exception is the model by Adda and Cornaglia (2010), who focus on the interplay among bans, taxes and passive smoking. Instead, several *empirical* papers have investigated the impact of taxation and other control policies on tobacco consumption (e.g., Chaloupka and Wechsler, 1997; Evans *et al.*, 1999, Adda and Cornaglia, 2006, Chaloupka *et al.*, 2010, Chaloupka *et al.*, 2012). A comprehensive discussion of the issues involved in tobacco regulation is in Gruber (2001).

[3] There are, instead, some *empirical* papers investigating the impact of lobbying by the tobacco industry on policy choices (e.g., Givel and Glantz, 2001; Morley *et al.*, 2002).

consumption with its future health harm, and (iii) *smoking bans,* such as free-air laws, that directly restrict consumption. Our theoretical model of smoking behavior is based on the framework developed by O'Donoghue and Rabin (2005, 2006) and Kőszegi (2005) to examine the socially optimal level of taxation of a harmful good.[4] We extend their setup in three directions, namely (i) by introducing the two regulatory instruments referred to above,[5] (ii) by assuming that tobacco is traded in an oligopolistic market, instead of a perfectly competitive one, and (iii) by considering the role of special interest groups.[6]

First, we take a normative perspective and study the optimal mix between the three types of instruments assuming that a benevolent policy maker maximizes the aggregate surplus of the economy. We then move to a positive perspective by allowing for the possibility that the choices of the planner are influenced by interest groups representing the parties affected by control policies: tobacco producers, smokers and non-smokers. We thus evaluate the distortions in public policy, if any, induced by lobbying activities.

We consider a population partitioned into two groups of individuals: smokers and non-smokers. Smokers' are assumed to be heterogeneous along several dimensions, such as the intensity of preferences for smoking, the size of future health harms caused by current tobacco consumption, the degree of self-control in smoking, and the sensibility to public awareness programs. We also distinguish between smoking causing external harms to other individuals (like that occurring indoor) and that imposing no external costs (like that occurring outdoor). Regulation, in the form of smoking bans aimed at curbing external costs, is applicable only to the former category of tobacco consumption, with smokers differing also in terms of the costs suffered to comply with the ban.

[4] Other models, in particular Gruber and Kőszegi (2004), provide a more articulated characterization of tobacco consumption, focusing also on dynamic issues. Bernheim and Rangel (2004) develop a framework, based on evidence from neuroscience, in which the consumption of harmful goods is due to 'mistakes' that are triggered by environmental cues. Their model is particularly appropriate for the analysis of consumption of highly addictive substances.

[5] O'Donoghue and Rabin (2006) refer primarily to junk food, while Kőszegi (2005) focuses also on beneficial goods (like exercise) and on the role of market solutions (two-part tariffs, non-linear pricing) besides public intervention. As for taxation and prevention programs, also our analysis can accommodate harmful goods different from tobacco, like alcoholic drinks, drugs, or unhealthy food. Regulation by means of smoke-free air laws is instead obviously specific to tobacco consumption.

[6] Also Haavio and Kotakorpi (2011) introduce political-economy considerations into the framework of O'Donoghue and Rabin (2006), but by means of a median-voter model.

Our normative analysis shows how prevention policies and smoking restrictions can usefully complement taxation in controlling tobacco consumption. Ideally, a set of individual-specific taxes (i.e., taxes tailored to match the characteristics of individual smokers and the possible externalities) would allow to implement an allocation that is first-best efficient, hence making other instruments redundant. However, individual-specific taxes are unfeasible in practice, because of lack of information and high administrative costs. Therefore, policy makers must rely on a second-best uniform tax on all smokers, which in turn calls for the introduction of additional policy instruments targeting specific inefficiencies. Our analysis shows how prevention programs and smoking restrictions, although unable to restore the first-best for the same reasons indicated above, prove very useful in mitigating the inefficiencies that are left unaddressed by uniform taxation.

In particular, our results show that the optimal excise tax is a sufficient instrument for correcting the inefficiencies arising from the behavior of the 'average' smoker and those stemming from the market power of tobacco producers. However, by targeting the average smoker, the optimal uniform tax does not properly account for individuals' heterogeneity in terms of health harms, degree of self-control, receptiveness to prevention programs. Furthermore, by simply correcting for the average external harm, it does not properly account for the fact that different acts of smoking in unregulated contexts may exert different external harms to other individuals.[7]

As for prevention policies, we show that their optimal level crucially depends on the variance of health harms for smokers. Intuitively, for the smokers suffering an health harm above the average level, it is socially beneficial to induce a further decrease in tobacco consumption, in addition to the one already achieved through taxation. The opposite holds for smokers with health harm below the average. This is exactly what can be achieved through prevention policies, the introduction of which, coupled with an appropriate reduction in taxation, is therefore useful for increasing the efficiency of tobacco control policies.

As for smoking restrictions, we show that they represent an additional useful in-

[7] As it will become clear later on, in our model, the fact that the optimal tax targets the average smoker depends on the assumed linear functional forms for health harms with respect to tobacco consumption. With strictly convex functions, the analysis would be more complex (instead of average values, the optimal tax would depend on mean-variance indexes of the key parameters) but the essence of the results would not change. The issue of the functional specification for health costs is briefly discussed in Kőszegi (2005, p. 78).

strument for curbing smoking externalities that are only partially corrected by uniform taxation, since the latter — by correcting for the average externality — is unable to account for the different external costs caused by smokers in different environments. However, it is never optimal extending smoking bans to all situations in which tobacco consumption causes external costs. The optimal degree of (incomplete) regulation imposes a ban on smoking where it generates an externality larger than a given threshold, but no ban where the externality is below it. Note that also smoking bans are second best policies. On the one hand, they impose zero tobacco consumption where the external costs are relatively large, while it should only be reduced to its efficient positive level in the first best allocation. On the other hand, they leave consumption unrestricted where the external costs are relatively low, with the result that consumption is above its efficient level.

Our final set of results concerns the impact on policy outcomes of the lobbying activities of tobacco producers, smokers, and non-smokers, organized as pressure groups aiming at bending tobacco control policies towards their interests. We show that producers concentrate their lobbying effort mainly on taxation, while lobbying on prevention policies and regulation appears to be appealing to citizens only. In particular, all interested parties actively lobby for affecting tobacco taxation, with results that obviously depend on their relative strengths as lobbying actors. At the same time, the impact of lobbying on prevention policies and on smoking restrictions depends essentially on the contrasting preferences of non-smokers and smokers.

The rest of the paper is organized as follows. Section 2 presents a brief survey of the literature on tobacco taxation, as well as stylized facts supporting our interest on additional policy instruments. The model is introduced in Section 3. The socially optimal structure of control policies is derived in Section 4, while the effects of lobbying are investigated in Section 5. Section 6 concludes.

2 Related literature and stylized facts

The pros and cons of tobacco taxation. Most of the available literature focuses exclusively on the role of taxation for regulating tobacco consumption. There are at least three 'traditional' arguments that are advocated in favor of tobacco taxation. First, it constitutes a good source of tax revenue (being a relatively simple levy to administer) both at the central and at the sub-central levels of government. Second, it represents a simple way to have smokers paying for the pecuniary externalities they impose on society, mainly due to the extra health care costs that are necessary to treat smoking related diseases. Third, taxation is often motivated by the paternalistic view building on the value of discouraging tobacco consumption, seen as a harmful good that would otherwise be consumed in excessive quantities by 'boundedly rational' consumers. This paternalistic view has been forcefully criticized by Becker and Murphy (1988) based on the idea of rational addiction. According to their view, as smoking habits are the result of optimizing choices by rational agents, there is no need to reduce demand by levying taxes on tobacco. Among the other arguments against tobacco taxation, a very popular one holds that its burden is regressive, since cigarettes consumption accounts for a larger share of the income of poor households. Such taxes are therefore also criticized on equity grounds.

The more recent literature has both refreshed and challenged the traditional view just outlined along several dimensions (see, e.g., Gruber and Kőszegi (2008) for a comprehensive non-technical survey). First, the premise that smokers may not behave in a fully rational way has been revived by building on the theory of intertemporal choices with hyperbolic discounting (on the latter, see, among others, Laibson, 1997). For instance, the models developed by Gruber and Kőszegi (2004), and by O'Donoghue and Rabin (2006), provide a rigorous underpinning of the role that taxation can play in correcting time inconsistent choices by the consumers of a harmful good. Second, some authors (e.g., Gruber and Kőszegi, 2008) reject the pecuniary externality argument in favor of tobacco taxation. In particular, they hold that the burden on health care systems to treat smoke-related diseases is approximately of the same magnitude as the savings on retirement expenditures, since smokers have a shorter life expectation than non-smokers (see also Crawford *et al.*, 2010, for a critical assessment of the empirical literature about the estimation of the net costs of smoking). Third, Gruber and Kőszegi (2004) provide another important challenge to the traditional view on tobacco taxation, by arguing that the taxation of cigarettes consumption may show a burden profile that is, in welfare terms, progressive. The intuition is simple. In a setting of time inconsistent behavior, tobacco taxation plays a corrective role by reducing over-consumption. However, since low income consumers are more sensitive to tax induced price changes than high income consumers, taxation may turn out to benefit more the low than the high income individuals, hence showing a progressive pattern in terms of welfare gains.

Tobacco control policies: empirical evidence. The available empirical evidence for the USA, summarized in Table 1, shows that non-price control policies are widely used in addition to taxes as instruments to regulate tobacco consumption.

<Insert Table 1 about here>

The table reports the latest publicly available data on each excise state tax per pack of cigarettes, on the per capita amount of state tax revenue from cigarette sales, on the per capita funds allocated for tobacco control programs, on the so called total Alciati score (measuring the extensiveness of state tobacco control youth access laws), and on an index of smoke-free air laws (measuring the level of smoking restrictions by state law).[8] Although there is a large heterogeneity among states — both in the extent and in the mix of the adopted measures — it is evident that policy makers do not rely exclusively (or even primarily) on taxation to restrict tobacco consumption, but rather combine a variety of different instruments. It is therefore important, in a theoretical perspective, to properly account for these instruments, moving behind a framework that only focuses on the role of taxes.[9]

The theoretical analysis we develop in the paper considers explicitly also the role of lobbying and of its effects on the policy interventions regulating tobacco consumption. This is again motivated on empirical grounds. Table 2 shows the importance of lobbying by tobacco industry related lobbies in the U.S.A., by reporting their total contributions to candidates and committees at the federal, state and local level over the period 2004-2014. For the sake of comparison, the table also reports the contributions of two other

[8] Although the latest available data on state tax revenue (REV) are for fiscal year 2013, in Table 1 we report the 2011 data in order to make a consistent comparison with the latest available data on control programs (TCP). Note also that the table reports only empirical observations on tobacco control policies undertaken by the U.S. States, although similar policies are implemented also at the federal and at the local levels of government. For instance, in addition to state taxes, there is a Federal excise tax of $1.01 per pack (since April 1, 2009) and, in some states, also a tax levied at the county and/or city levels. Note that, as largely expected, tobacco-producers states have both lower taxation and a lower reliance on other control policies.

[9] Similar evidence is available for the European Union, where data on excise duties on tobacco are periodically released by the European Commission (http://ec.europa.eu/taxation_customs/taxation/excise_duties/index_en.htm). The evolution of the European legislation on smoking bans is illustrated by the European Public Health Alliance (EPHA, http://www.epha.org/a/1941).

sectors subject to excise taxation, the oil and gas sector and the alcoholic beverage sector. Overall, the contributions of the tobacco sector are similar in size to those of the alcoholic beverage sector, while those of the oil and gas sector are twice as big. The table also reports the excise tax revenues at the federal, state and local level for the three sectors over the period 2004-2011. The reported figures show that the share of political contributions to tax revenue is equal to .071% of tax revenue in the tobacco sector, in between the .053% for the oil and gas sector and the .145% for alcoholic beverages.

<Insert Table 2 about here>

While it is relatively easy to find data on campaign contributions of lobby groups linked to the tobacco industry, it is way more difficult to obtain information on pressure groups (such as non-profit or voluntary citizens' organizations) that lobby for stricter taxation and regulation policies.[10] A specific instance in which it is possible to explicitly compare the efforts made by lobbies having opposite views on tobacco control policies is to look at the donations made by various groups to influence the outcome of ballot measures on tobacco related issues (in the 24 states where ballot measures are allowed). Table 3 shows the contributions raised by lobby groups that opposed or favored ballot measures in the U.S. states over the period 2002–2012.[11]

<Insert Table 3 about here>

Two considerations are worth making. First, it emerges that not only tobacco producers and manufacturers are active in lobbying, but that also anti-tobacco interest groups are able to pledge a considerable amount of financial resources to voice their concerns. Second, it appears that lobbying is quantitatively more important when

[10] The reason is that in many cases these organizations lobby to achieve multiple goals, and it may be difficult to disentangle the actual contributions pledged towards a specific issue. For instance, organizations such as the American Cancer Society lobby both for stricter regulation on tobacco consumption and for increased cancer prevention programs funding that is not necessarily related to smoking habits.

[11] Obviously, lobbying needs not occur at the state level only. Therefore, the figures in Table 3 – not accounting for lobbying at the federal or local level – are likely to understate the extent of the phenomenon.

ballot measures deal mainly or exclusively with changes in tax rates rather than on control policies. This is particularly interesting as it is consistent with a finding of our theoretical model highlighting that lobbying impacts mainly on tobacco taxation, while it bears a modest impact on prevention programs and on smoking restrictions.

3 The model

Our theoretical framework extends those by O'Donoghue and Rabin (2005, 2006) and Kőszegi (2005), in which taxation is the only policy instrument for controlling tobacco consumption, by adding prevention policies and free-air legislation to the set of available policy tools. This broadening of the analysis requires an appropriate characterization of preferences for smoking, which is provided in Section 3.1. Section 3.2 derives the market equilibrium. Finally, the representation of individual and aggregate surplus in Section 3.3 opens the way to the normative analysis that is developed in Section 4.

3.1 The consumption sector

We consider a population divided into two, exogenously given, groups: that of smokers, of mass $m \in (0, 1)$, and that of non-smokers, of mass $1 - m$.

Modeling preferences for smoking requires recognizing that cigarettes consumption does not entail decreasing marginal utility on temporally subsequent units of consumption. Instead, the 'pleasure' enjoyed from smoking cigarettes follows a random process on the time line. In fact, a smoker may enjoy greater pleasure from the $(n + 1)$-th than from the n-th cigarette of the day, depending on a variety of circumstances. For instance, smoking after lunch may be more enjoyable than smoking in the morning while commuting to work.

The presence of smoking restrictions in the form of free air laws and regulations also plays a role in affecting the pleasure derived from smoking a cigarette. In this respect, the crucial feature is that a smoking restriction is not equivalent to consumption rationing. Consider, for instance, a smoking ban in restaurants. The fact that smoking is forbidden within a restaurant premises does not imply a ceiling on cigarettes consumption. Clearly, a smoker can always opt for increasing the number of cigarettes consumed before and/or after the meal, or she can have a break during the meal going outside the restaurant to smoke. Therefore, what is relevant about smoking restrictions are the costs they impose on smokers in terms of reduced pleasure from smoking. In the example, it is likely that a smoker would take greater pleasure from smoking inside the restaurant than having to do it outside.

We formalize these ideas by building a model in which smokers consume two types of goods: a harmful good x (i.e., cigarettes) and a 'standard' consumption good z. Non-smokers consume only good z. Each unit of good z provides a constant gross surplus to consumers, the size of which is normalized to one. As for the other good, let s be the gross surplus (i.e., the immediate pleasure) of consuming one unit of x (i.e., smoking a cigarette) whenever smoking occurs in a location not subject to smoking restrictions. In any given period of time, s is assumed to be uniformly distributed on the closed interval $[0, 1/\rho_1]$, with $\rho_1 > 0$. Therefore, the inverse of the parameter ρ_1 captures the 'intensity' of smoking preferences, as $1/\rho_1$ represents the maximum level of pleasure that an individual can enjoy from smoking a cigarette. If, instead, tobacco consumption occurs in a location that is subject to a smoking ban, it is assumed that gross surplus is uniformly distributed on the closed interval $[-\xi, 1/\rho_1 - \xi]$, where $0 < \xi < 1/\rho_1$. The parameter ξ represents the cost, in terms of forgone pleasure, that is incurred by complying with the smoking ban (for instance, smoking outside the restaurant), which we assume for simplicity to be enforced perfectly and at no cost. We further denote with $\rho_0 > 0$ the 'volume' of tobacco consumption (see Footnote 14 below).

We assume that an exogenous share $\alpha \in (0, 1)$ of consumption occurs in locations that could be subject to smoking restrictions due to the negative externalities imposed on other individuals by smokers (that we will formally define in Section 3.3). The actual restriction on consumption in these locations is denoted by a parameter $r \in [0, 1]$, capturing the degree of regulation. Hence, overall, consumption in unrestricted locations is a share $1 - \alpha r$ of total consumption, while that in restricted locations is given by αr.

Present smoking provokes future harm for health, which is assumed to take a linear form. More precisely, the present value of future harm for each unit of current consumption is assumed being equal to $\beta\gamma$, where the parameter $\gamma \geq 0$ represents the present value of health harm, and the hyperbolic-discounting parameter $\beta \in [0, 1]$ captures (in a reduced form) the degree of time inconsistency, or of lack of self-control, in consumer behavior;[12] $\beta < 1$ implies overconsumption with respect to its efficient level,

[12]The assumption that smokers may lack self control (i.e., $\beta < 1$) while they are correctly informed about the true risks due to tobacco use (i.e., the value of γ) is consistent with recent evidence reported by Khwaya *et al.* (2009). Smokers' time preferences, time discounting, and abilities to plan, are instead

whereas $\beta = 1$ implies fully rational behavior.

Differently from O'Donoghue and Rabin (2006) and Kőszegi (2005), who take it as exogenously given, we assume that the parameter β is endogenously determined by the variable θ, representing a policy instrument that the regulator can use to affect the consumption of the harmful good. For instance, if the government launches a campaign against tobacco use, the degree of smokers' self-control in taking consumption decisions may increase, an outcome that is reflected in higher levels of β. In particular, we assume that $\beta(\theta) = b + k\theta$, where the parameter $b \in [0, 1]$ represents the component of β that is independent of θ, whereas the parameter $k \geq 0$ captures the sensitivity of individual self consciousness to the policy instrument θ.

Each individual (either a smoker, or a non-smoker) is endowed with an exogenously given income I and receives a lump sum transfer ℓ from the government, equal for all individuals, which is defined in Eq. (17) below. Good z is taken to be the *numeraire* and p denotes the unit market price of good x. Both ℓ and p are taken as given by the consumer. Finally, we assume that in any given period of time the total gross surplus from smoking is equal to the sum of the gross surpluses from the various consumption units.

Under the assumptions above, a smoker aiming at maximizing her total net surplus will eventually consume only those units of x for which she derives a gross surplus s that is larger than or equal to $p + \beta\gamma$, and use the residual income to buy good z. As we show in Appendix A.1, this is equivalent to maximize the utility function

$$u(x^{\mathrm{u}}, x^{\mathrm{r}}, z) = (1 - \alpha r)v^{\mathrm{u}}(x^{\mathrm{u}}) + \alpha r v^{\mathrm{r}}(x^{\mathrm{r}}) - \beta(\theta)\gamma x + z, \tag{1}$$

subject to the budget constraint

$$z \leq I + \ell - px, \tag{2}$$

where

$$v^{\mathrm{u}}(x^{\mathrm{u}}) = \frac{1}{\rho_1}\left(1 - \frac{x^{\mathrm{u}}}{2\rho_0}\right)x^{\mathrm{u}}, \qquad v^{\mathrm{r}}(x^{\mathrm{r}}) = \frac{1}{\rho_1}\left(1 - \xi\rho_1 - \frac{x^{\mathrm{r}}}{2\rho_0}\right)x^{\mathrm{r}},$$
$$x = (1 - \alpha r)x^{\mathrm{u}} + \alpha r x^{\mathrm{r}}, \qquad \beta(\theta) = b + k\theta,$$

and x^{u}, x^{r} denote consumption in unrestricted and restricted locations, respectively.

The smokers' population is composed of a continuum of heterogeneous individuals, each one characterized by a vector $\Upsilon = (\rho_0, \rho_1, \xi, b, k, \gamma)$ of individuals' attributes. The

critically assessed in Khwaya *et al.* (2007a, 2007b).

cumulative distribution of types is $F(\Upsilon)$ and we assume that all individual attributes belonging to Υ are independently distributed.[13] We denote with $\bar{y} \equiv \mathrm{E}_F[y]$ the expected value of the variable y, with y element of Υ. Notice that $\bar{y}$ is the per capita value of y for the group of smokers. Since the latter group has mass m, the per capita value of y for the entire population (smokers and non-smokers) is equal to $m\bar{y}$, where we let $y = 0$ for non-smokers without loss of generality. Note finally that we assume that α is single valued; i.e., it takes the same value for all smokers.

3.2 Market equilibrium

From the first order conditions for maximizing Eq. (1), subject to Eq. (2), we obtain the individual demands for cigarettes in unrestricted and restricted locations

$$x^{\mathrm{u}}(p;\theta) = \rho_0 - \rho_0\rho_1(\beta(\theta)\gamma + p), \qquad x^{\mathrm{r}}(p;\theta) = \rho_0 - \rho_0\rho_1(\beta(\theta)\gamma + \xi + p), \tag{3}$$

respectively, where the arguments of the vector Υ are dropped to simplify notation whenever possible.[14] Note that $x^{\mathrm{u}}(p;\theta) > x^{\mathrm{r}}(p;\theta)$. Total individual demand is equal to

$$x(p;\theta,r) = \rho_0 - \rho_0\rho_1(\beta(\theta)\gamma + \xi\alpha r + p). \tag{4}$$

Aggregate demand (which is equal to smokers' per capita demand) is then equal to

$$X(p;\theta,r) = \bar{\rho}_0 - \bar{\rho}_0\bar{\rho}_1(\bar{\beta}(\theta)\bar{\gamma} + \bar{\xi}\alpha r + p), \qquad \bar{\beta}(\theta) = \bar{b} + \bar{k}\theta,$$

while the inverse aggregate demand is

$$p(X;\theta,r) = \frac{1}{\bar{\rho}_1} - \bar{\beta}(\theta)\bar{\gamma} - \bar{\xi}\alpha r - \frac{1}{\bar{\rho}_0\bar{\rho}_1}X. \tag{5}$$

For given values of θ, the aggregate demand $X(p;\theta,r)$ is defined only for values of p such that the individual demand $x^{\mathrm{r}}(p;\theta)$ is non-negative for all consumers types. As we further discuss below, in order to simplify the analysis we rule out the possibility of corner solutions in which individual demand is zero for some consumers.

Good z is produced in a competitive market, while good x is produced in an oligopolistic market, which is characterized by a fixed number, $n \geq 1$, of quantity-setting

[13] Note that the model can be solved also when individual attributes are correlated, at the cost, however, of deriving less clear-cut results.

[14] The expression for $x^{\mathrm{u}}(p;\theta)$ shows that the parameter ρ_0 represents the amount of cigarettes that would be consumed in the given period of time by a smoker who is allowed to buy cigarettes at zero price ($p = 0$) and who does not internalize future health harms ($\beta = 0$).

identical firms competing *à la* Cournot. There is a specific (excise) tax at rate t on cigarettes consumption, levied on producers. Production costs are linear, with constant marginal costs, $c > 0$, equal to average costs.

Firm j maximizes its profit function with respect to the quantity it produces, x_j, taking as given the quantities produced by the other firms; i.e.

$$\max_{x_j} \pi_j = (p(X; \theta, r) - c - t)\, x_j, \quad \text{where } X = \sum_{i=1}^{n} x_i. \tag{6}$$

By taking the first order condition of Problem (6) with respect to x_j, we obtain[15]

$$\frac{1}{\bar{\rho}_1} - \bar{\beta}(\theta)\bar{\gamma} - \bar{\xi}\alpha r - c - t - \frac{1}{\bar{\rho}_0\bar{\rho}_1}\left(\sum_{i \neq j} x_i + 2x_j\right) = 0, \quad j = 1, \ldots, n. \tag{7}$$

Summing Eq. (7) over $j = 1, \ldots, n$, we have

$$n\left(\frac{1}{\bar{\rho}_1} - \bar{\beta}(\theta)\bar{\gamma} - \bar{\xi}\alpha r - c - t\right) - \frac{1}{\bar{\rho}_0\bar{\rho}_1}\left((n-1)X + 2X\right) = 0.$$

From the latter equation, we then obtain the equilibrium aggregate quantity as a function of the policy instruments:

$$X^*(t, \theta, r) = \frac{n}{1+n}\bar{\rho}_0\left(1 - \bar{\rho}_1\left(\bar{\beta}(\theta)\bar{\gamma} + \bar{\xi}\alpha r + c + t\right)\right). \tag{8}$$

Since firms are identical, the market equilibrium is symmetric. By substituting $X^*(t, \theta, r)$ into Eq. (5) and solving for p, we get the equilibrium consumers' price

$$p^*(t, \theta, r) = \frac{n}{1+n}(c+t) + \frac{1}{1+n}\left(\frac{1}{\bar{\rho}_1} - \bar{\beta}(\theta)\bar{\gamma} - \bar{\xi}\alpha r\right). \tag{9}$$

We assume that, for any given triplet (t, θ, r) of policy instruments, the elements of the vector Υ are such that $x^{\mathrm{r}}(p^*; \theta) > 0$ for all types, implying that all individuals are smokers at all equilibrium prices.[16] In turn, this implies a well defined market equilibrium, with $X^*(t, \theta, r) > 0$ and $p^*(t, \theta, r) > 0$. Notice that aggregate consumption is decreasing in the policy parameters t, θ and r. However, while the tax rate t, by

[15] Under the given hypotheses (linear demand and linear production costs) the necessary first order conditions for profit maximization are also sufficient. Moreover, Stern's (1987) market equilibrium stability condition is also satisfied.

[16] This assumption rules out corner solutions in which the consumption of the harmful good is zero for some potential smokers. While it is possible to allow for an endogenous partition of smokers into 'active' and 'non-active' tobacco consumers, the extension would complicate the analysis without adding much to the main message of the paper.

augmenting firms' marginal costs, increases the consumers' price, anti-tobacco policies θ and smoking restrictions r decrease it because they reduce the aggregate demand without imposing a direct cost on producers.

By substituting p^* from Eq. (9) into Eq. (4) we get individual total consumption,

$$x^*(t,\theta,r) = \rho_0 - \rho_0\rho_1(\beta(\theta)\gamma + \xi\alpha r + p^*(t,\theta,r)), \tag{10}$$

as a function of the policy parameters and of individual type. It is then immediate to see that:

$$\frac{\partial x^*}{\partial t} = \frac{\partial x}{\partial p}\frac{\partial p^*}{\partial t} = -\frac{n}{1+n}\rho_0\rho_1 < 0, \tag{11}$$

$$\frac{\partial x^*}{\partial \theta} = \frac{\partial x}{\partial p}\frac{\partial p^*}{\partial \theta} + \frac{\partial x}{\partial \theta} = \left(\frac{1}{1+n}\bar{k}\bar{\gamma} - k\gamma\right)\rho_0\rho_1 \lesseqgtr 0 \quad \text{iff} \quad \gamma \gtreqless \frac{\bar{k}}{k}\frac{\bar{\gamma}}{(1+n)}, \tag{12}$$

$$\frac{\partial x^*}{\partial r} = \frac{\partial x}{\partial p}\frac{\partial p^*}{\partial r} + \frac{\partial x}{\partial r} = \alpha\left(\frac{1}{1+n}\bar{\xi} - \xi\right)\rho_0\rho_1 \lesseqgtr 0 \quad \text{iff} \quad \xi \gtreqless \frac{\bar{\xi}}{1+n}. \tag{13}$$

Proposition 1 follows immediately from Eqs. (11) – (13).

Proposition 1 *Taxation reduces individual consumption of all types. Prevention policies reduce (increase) consumption for those types with harm γ greater (smaller) than $\frac{\bar{k}}{k}\frac{\bar{\gamma}}{(1+n)}$. Smoking restrictions reduce (increase) consumption for those types experiencing a cost ξ for complying with the regulatory restriction greater (smaller) than $\frac{\bar{\xi}}{1+n}$.*

Taxation has the obvious effect of increasing consumers' price, which reduces the consumption of all types. The intuition behind the other results is also simple. An increase in θ reduces aggregate demand and therefore the equilibrium price. However, for those smokers with a low γ the reduction in price causes an increase in demand that outweighs the reduction due to a higher θ. Similarly, for the individuals for whom complying with a regulatory ban is not particularly costly, the increase in demand caused by the reduction in price induced by higher regulation more than compensates the reduction of demand directly associated to it. Note that under perfect competition only the direct effect on individual demands is present in Eqs. (12) and (13), since θ and r do not impact on the equilibrium price p^*, hence reducing consumption x^* for all types.

Observe finally that the impact of θ and r is isomorphic to that of t; i.e.

$$\frac{\partial X^*}{\partial t} = \mathrm{E}_F \left[\frac{\partial x^*}{\partial t} \right] = -\frac{n}{1+n} \bar{\rho}_0 \bar{\rho}_1 < 0, \tag{14}$$

$$\frac{\partial X^*}{\partial \theta} = \mathrm{E}_F \left[\frac{\partial x^*}{\partial \theta} \right] = \bar{k} \bar{\gamma} \frac{\partial X^*}{\partial t} < 0, \tag{15}$$

$$\frac{\partial X^*}{\partial r} = \mathrm{E}_F \left[\frac{\partial x^*}{\partial r} \right] = \alpha \bar{\xi} \frac{\partial X^*}{\partial t} < 0, \tag{16}$$

which is a useful property of the impact of policy instruments on the aggregate tobacco consumption.

3.3 Individual and aggregate welfare

We assume, as it is standard in the literature, that the revenue raised by taxing tobacco consumption, $tX^*(t, \theta, r)$, net of the expenditures for financing prevention policies, $(\phi/2)\theta^2$ with $\phi \geq 0$, is given back to consumers (both smokers and non-smokers) in a lump sum form. Hence, for the entire population, the transfer in per capita terms is equal to

$$\ell^*(t, \theta, r) = m \left(tX^*(t, \theta, r) - \frac{\phi}{2} \theta^2 \right). \tag{17}$$

Note that we abstract from the administrative costs of taxation, again as it is standard in the literature on optimal taxation. Furthermore, we assume that there are no direct costs associated to the enforcement of smoking restrictions.

Using Eqs. (1) and (2), the net surplus of a smoker can be defined as

$$w^* = (1 - \alpha r) v^{\mathrm{u}}(x^{*\mathrm{u}}) + \alpha r v^{\mathrm{r}}(x^{*\mathrm{r}}) - \gamma x^* - p^* x^* + \ell^* - m\Gamma^* + I, \tag{18}$$

in which we suppress the arguments t, θ and r from all the 'starred' equilibrium variables to simplify the notation. Note that the 'full' harm, γx^*, enters the definition of individual welfare in Eq. (18) in place of its hyperbolically discounted measure, $\beta \gamma x^*$, which instead enters the utility function in Eq. (1). Consistently with Kőszegi (2005), Eq. (1) represents smokers' utility with smoking occurring in the present, under the pressure for immediate gratification, and harm in the future. Instead, Eq. (18) represents the utility with smoking and harm occurring both in the future. By the theory of hyperbolic discounting (Laibson, 1997), individuals do not bias their choices in favor of immediate gratification when consumption is planned in the future, since the marginal rate of substitution between future pleasure from smoking and future health harm is

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the correct one. However, at the time when consumption actually occurs, smokers take distorted choices, since the marginal rate of substitution between current pleasure from smoking and future health harm is biased in favor of immediate gratification. Hence, while actual consumers' choices are described by the utility function (1), their welfare can be measured through the utility function (18), which expresses the preferences of a fully self-controlled (perfectly time consistent) individual.

Another crucial element affecting individual welfare is the externality Γ^* that smokers impose on other individuals (for instance, in the form of health harm arising from second-hand smoke), which is defined in aggregate terms as

$$\Gamma^* = \eta(r)\alpha\,(1-r)\,X^{*\mathrm{u}}, \qquad \eta(r) = \eta_0\,(1-r)\,, \tag{19}$$

where $\eta_0 > 0$ and $X^{*\mathrm{u}} = \bar{\rho}_0 - \bar{\rho}_0\bar{\rho}_1(\bar{\beta}(\theta)\bar{\gamma} + p^*)$ is obtained by aggregating the individual demands $x^{\mathrm{u}}(p;\theta)$, defined in Eq. (3), evaluated at the equilibrium price p^*. Note that, according to Eq. (18), each smoker uniformly imposes an externality to all other individuals, smokers and non-smokers. In our linear framework, it is easy to see that the same aggregate implications would emerge were the externality to affect differently different individuals.

The policy instruments impact on the externality as follows:

$$\frac{\partial \Gamma^*}{\partial t} = \eta\alpha(1-r)\frac{\partial X^{*\mathrm{u}}}{\partial p^*}\frac{\partial p^*}{\partial t} < 0, \tag{20}$$

$$\frac{\partial \Gamma^*}{\partial \theta} = -\eta\alpha(1-r)\bar{\rho}_0\bar{\rho}_1\left(\frac{\partial\bar{\beta}}{\partial\theta}\bar{\gamma} + \frac{\partial p^*}{\partial\theta}\right) < 0, \tag{21}$$

$$\frac{\partial \Gamma^*}{\partial r} = \eta\alpha(1-r)\frac{\partial X^{*\mathrm{u}}}{\partial p^*}\frac{\partial p^*}{\partial r} - \alpha\left(\eta - (1-r)\frac{\partial\eta}{\partial r}\right)X^{*\mathrm{u}} \lesseqgtr 0. \tag{22}$$

Higher taxation and larger prevention programs, by reducing aggregate tobacco consumption, reduce the level of the aggregate externality. Instead, stricter smoking restrictions have two contrasting effects on the externality. On the one hand, by widening the set of locations in which smoking is not allowed, they reduce the level of external costs (the second addendum in Eq. 22); on the other hand, by lowering the price of cigarettes, they stimulate tobacco consumption in the locations that are not subject to the smoking ban, which in turn increases external costs (the first addendum in Eq. 22).

Remark. Several assumptions underline the formulation of the externality defined in Eq. (19). The locations in which smoking causes a damage to other individuals are ranked, in decreasing order, according to the level of externalities they give rise to. On the unit line, we let the linearly decreasing function $\tilde{\eta}(L) = 2\eta_0 (1 - L)$ to represent the externality per unit of tobacco consumption on the ordered locations $L \in [0, 1]$. The highest level of the externality is $2\eta_0$, at location $L = 0$; the lowest is zero, at location $L = 1$. We further assume that tobacco consumption is uniformly distributed on locations $L \in [0, 1]$ and that the policy instrument $r \in [0, 1]$, representing smoking restrictions, maps one-to-one on the ordered set of locations. Therefore, for any given degree r of smoking restrictions, the externalities are neutralized in all locations $L \in [0, r]$ in which smoking is forbidden (the locations with relatively large externalities), whereas they are allowed in the remaining locations $L \in (r, 1]$ (with relatively small externalities). The function $\eta(r)$ shown in Eq. (19) then represents the average externality generated by each unit of consumption in the unregulated locations; i.e., $\eta(r) = (1 - r)^{-1} \int_r^1 \tilde{\eta}(L)\,\mathrm{d}L$. Finally, recalling that α represents the exogenous share of total tobacco consumption that occurs in locations where externalities are produced in case of smoking, and that $X^{*\mathrm{u}}$ is aggregate consumption in unrestricted locations, we see that $\alpha\,(1 - r)\,X^{*\mathrm{u}}$ is equal to aggregate consumption in the unregulated externality-generating locations. The aggregate externality Γ^* is then equal to aggregate consumption $\alpha\,(1 - r)\,X^{*\mathrm{u}}$ times the average externality $\eta(r)$ per unit of consumption.

By substituting ℓ^* from Eq. (17), adding and subtracting $(p - c - t)x^*$, and adding and subtracting $\beta\gamma x^*$, Eq. (18) can be written as

$$w^* = u^* - (1-\beta)\gamma x^* + (p^* - c)x^* - m\Gamma^* + t(mX^* - x^*) - (p^* - c - t)x^* - m\frac{\phi}{2}\theta^2 + I, \quad (23)$$

where

$$u^* = (1 - \alpha r)v^{\mathrm{u}}(x^{*\mathrm{u}}) + \alpha r v^{\mathrm{r}}(x^{*\mathrm{r}}) - \beta\gamma x^* - p^* x^*. \quad (24)$$

Note that, by standard envelope arguments, we have that

$$\frac{\partial u^*}{\partial t} = -x^* \frac{\partial p^*}{\partial t}, \quad (25)$$

$$\frac{\partial u^*}{\partial \theta} = -\left(k\gamma + \frac{\partial p^*}{\partial \theta}\right) x^*, \quad (26)$$

$$\frac{\partial u^*}{\partial r} = -x^* \frac{\partial p^*}{\partial r} - \alpha\left[v^{\mathrm{u}}(x^{*\mathrm{u}}) - v^{\mathrm{r}}(x^{*\mathrm{r}})\right]. \quad (27)$$

As for non-smokers, they devote all their income, $I + \ell^*$, to the consumption of good z, with utility linearly increasing in z with unit slope. Hence, individual welfare is equal to

$$\tilde{w} = \ell^* - m\Gamma^* + I = m\left(tX^* - \frac{\phi}{2}\theta^2 - \Gamma^*\right) + I. \tag{28}$$

To compute social welfare, we adopt the Utilitarian criterion. Therefore, by aggregating the individual welfare levels shown in Eqs. (23) and (28), the per capita welfare level for the entire population is equal to

$$\begin{aligned} m\mathrm{E}_F\left[w^*\right] + (1-m)\tilde{w} = \\ = m\left(\mathrm{E}_F\left[u^* - (1-\beta)\gamma x^* + (p^* - c)x^*\right] - \Gamma^* - \Pi^* - \frac{\phi}{2}\theta^2\right) + I, \end{aligned} \tag{29}$$

where the aggregate equilibrium profits, Π^*, are equal to

$$\Pi^* = (p^* - c - t)X^*. \tag{30}$$

By adding per capita profits, $m\Pi^*$, to per capita welfare (i.e., net surplus) defined in Eq. (29), the per capita surplus of the economy is defined as[17]

$$\Omega^* = m\left(\mathrm{E}_F\left[u^* - (1-\beta)\gamma x^* + (p^* - c)x^*\right] - \Gamma^* - \frac{\phi}{2}\theta^2\right) + I. \tag{31}$$

4 Efficient policies

We assume that a benevolent policy maker sets the policy instruments with the aim of maximizing the per capita surplus defined in Eq. (31). Note that such social objective function implies that optimality is defined in terms of efficiency, so that distributional issues (between heterogeneous smokers, between smokers and non-smokers, and between consumers and profit earners) are ignored. The objective function (31) also shows that the efficient policy is independent of the proportion, m, of smokers in the total population. The relative weight of smokers and non-smokers can instead play a role when public policy is distorted by the lobbying activities of special interest groups, as we show in Section 5.

[17] Since aggregate firms' profits, Π^*, are part of the surplus of the economy, and since profits in per capita terms, $m\Pi^*$, are a negative component of consumers' surplus in per capita terms, in order to obtain the aggregate surplus of the economy in per capita terms we need to add per capita profits $m\Pi^*$ to Eq. (29). Assuming instead that profits are entirely distributed to consumers has no implications for the optimal policies derived in Section 4, as also in that case we would obtain exactly Eq. (31) as the objective function. However, for the analysis of lobbying in Section 5, it seems more appropriate to assume that profits are entirely retained by firms, so that their incentives to lobby are not perfectly aligned to those of consumers (smokers and non-smokers).

Instead of seeking the solution to the policy problem simultaneously for the three instruments, it is instructive to consider them separately, first characterizing the optimal tax rate t for given values of the other instruments, then turning to the determination of the prevention policies θ, and finally focusing on smoking restrictions r.

4.1 Taxation

By differentiating Eq. (31) with respect to t, we get

$$\frac{1}{m}\frac{\partial \Omega^*}{\partial t} = \mathrm{E}_F\left[\frac{\partial u^*}{\partial t} - (1-\beta)\gamma\frac{\partial x^*}{\partial t} + x^*\frac{\partial p^*}{\partial t} + (p^*-c)\frac{\partial x^*}{\partial t}\right] - \frac{\partial \Gamma^*}{\partial t}. \tag{32}$$

By rewriting Eq. (20) as

$$\frac{\partial \Gamma^*}{\partial t} = -\frac{n}{1+n}\bar{\rho}_0\bar{\rho}_1\eta_0\alpha(1-r)^2 = \eta_0\alpha(1-r)^2\frac{\partial X^*}{\partial t}, \tag{33}$$

using Eq. (25) to simplify the expression in the expectation operator, and then taking the expectation, Eq. (32) can be written as

$$\frac{1}{m}\frac{\partial \Omega^*}{\partial t} = -\left[(1-\bar{\beta})\bar{\gamma} - (p^*-c) + \eta_0\alpha(1-r)^2\right]\frac{\partial X^*}{\partial t}. \tag{34}$$

Since, using Eq. (9), we have that

$$p^* - c = \frac{n}{1+n}t + \frac{1}{1+n}\left(\frac{1}{\bar{\rho}_1} - \bar{\beta}\bar{\gamma} - \bar{\xi}\alpha r - c\right),$$

and given that $m > 0$ and $\partial X^*/\partial t < 0$, the first order necessary condition for the optimal tax rate can be written as

$$(1-\bar{\beta})\bar{\gamma} - \frac{n}{1+n}t - \frac{1}{1+n}\left(\frac{1}{\bar{\rho}_1} - \bar{\beta}\bar{\gamma} - \bar{\xi}\alpha r - c\right) + \eta_0\alpha(1-r)^2 = 0. \tag{35}$$

By solving (35) for t, we can immediately state the following proposition.

Proposition 2 *For given θ and r, the optimal tax rate is equal to*

$$t^*(\theta, r) = (1-\bar{\beta}(\theta))\bar{\gamma} + \alpha\eta_0(1-r)^2 - \frac{1}{n}\Psi(r), \tag{36}$$

where

$$\Psi(r) = \frac{1}{\bar{\rho}_1} - \bar{\gamma} - \bar{\xi}\alpha r - \alpha\eta_0(1-r)^2 - c > 0. \tag{37}$$

$t^*(.)$ is decreasing in $\bar{b}$ and $\bar{k}$, and increasing in $\bar{\gamma}$, η_0, α, n, $\bar{\rho}_1$ and $\bar{\xi}$. Furthermore, it is decreasing in θ, while an increase in r has an ambiguous effect on $t^*(.)$.

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Eq. (36) is composed of three terms. The first two are both positive and represent the Pigouvian components of the optimal tax rate. While the first term is equal to the average harm that consumers do not internalize because of lack of self-control, the second term is equal to the average externality per unit of consumption in locations not subject to smoking restrictions. Note that while an increase in θ reduces the first component of the Pigouvian tax, an increase in r reduces its second component.

The third term of Eq. (36) is instead negative, provided that Inequality (37) holds true. To see the meaning of the latter condition, notice first that by substituting $t^*(\theta, r)$ from Eq. (36) into Eq. (8), we immediately see that $X^*(t^*(\theta, r), \theta, r) > 0$ if and only if Inequality (37) is satisfied. That is, Condition (37) is a necessary and sufficient condition for having a positive level of aggregate consumption at the optimal tax policy $t^*(\theta, r)$. The economic interpretation of the inequality is simple. For the average smoker, the maximum level of pleasure from smoking, $1/\bar{\rho}_1$, has to exceed the sum of the average marginal health harm, $\bar{\gamma}$, the marginal cost of complying with smoking restrictions in regulated locations, $\bar{\xi}\alpha r$, the marginal externality generated by smoking in unregulated locations, $\alpha\eta_0(1-r)^2$, and the marginal cost of cigarettes production, c. In other words, if $\Psi(r) > 0$, then a positive level of tobacco consumption is efficient for the average smoker. The role of the third term of the optimal tax rate in Eq. (36) is then that of correcting for market power, since oligopoly pricing is above marginal cost. It is immediate to see that this term vanishes for $n \to \infty$, as the market approaches perfect competition . Note also that direct regulation r bears an ambiguous impact on this third component of the optimal tax rate.

Summing up, Eq. (36) shows that in general both a tax and a subsidy could be optimal. In practice, to the extent that internalities and externalities are more important than market imperfections, the optimal tax rate is expected to be positive.

4.2 Prevention policies

As for prevention policies, by differentiating Eq. (31) with respect to θ, we obtain

$$\frac{1}{m}\frac{\partial \Omega^*}{\partial \theta} = \mathrm{E}_F\left[\frac{\partial u^*}{\partial \theta} - (1-\beta)\gamma\frac{\partial x^*}{\partial \theta} + \left(k\gamma + \frac{\partial p^*}{\partial \theta}\right)x^* + (p^* - c)\frac{\partial x^*}{\partial \theta}\right] - \frac{\partial \Gamma^*}{\partial \theta} - \phi\theta. \quad (38)$$

Using Eq. (26) and the fact that Eq. (21) can be written as

$$\frac{\partial \Gamma^*}{\partial \theta} = \bar{k}\bar{\gamma}\frac{\partial \Gamma^*}{\partial t} = \bar{k}\bar{\gamma}\eta_0\alpha(1-r)^2\frac{\partial X^*}{\partial t}, \quad (39)$$

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Eq. (38) can be expressed as

$$\frac{1}{m}\frac{\partial \Omega^*}{\partial \theta} = -\mathrm{E}_F\left[[(1-\beta)\gamma - (p^* - c)]\frac{\partial x^*}{\partial \theta}\right] - \bar{k}\bar{\gamma}\eta_0\alpha(1-r)^2\frac{\partial X^*}{\partial t} - \phi\theta. \tag{40}$$

By taking the expectation, using Eqs. (12), (15), and (34), the derivative in Eq. (40) can be written as

$$\frac{1}{m}\frac{\partial \Omega^*}{\partial \theta} = -\mathrm{cov}\left((1-\beta)\gamma, \frac{\partial x^*}{\partial \theta}\right) + \bar{k}\bar{\gamma}\frac{1}{m}\frac{\partial \Omega^*}{\partial t} - \phi\theta. \tag{41}$$

With t optimally set, the third term of the above derivative is zero. Recalling that $\beta = b + k\theta$ and using Eq. (12), the covariance term in Eq. (41) is equal to

$$-\mathrm{cov}\left((1-\beta)\gamma, \frac{\partial x^*}{\partial \theta}\right) = \bar{\rho}_0\bar{\rho}_1\left[(1-\bar{b})\bar{k}\,\mathrm{var}(\gamma) - \theta\,\mathrm{var}(k\gamma)\right]. \tag{42}$$

Hence, with t optimally set, the first order necessary condition for the optimal level of prevention policies can be written as

$$\left.\frac{1}{m}\frac{\partial \Omega^*}{\partial \theta}\right|_{t=t^*(\theta,r)} = \bar{\rho}_0\bar{\rho}_1\left[(1-\bar{b})\bar{k}\,\mathrm{var}(\gamma) - \theta\,\mathrm{var}(k\gamma)\right] - \phi\theta = 0. \tag{43}$$

By solving Eq. (43) for θ, we get the following result.

Proposition 3 *With $t = t^*(\theta, r)$, the optimal level of prevention policies is given by*

$$\theta^* = \frac{(1-\bar{b})\bar{k}\,\mathrm{var}(\gamma)}{\phi/(\bar{\rho}_0\bar{\rho}_1) + \mathrm{var}(k\gamma)}, \tag{44}$$

where $\mathrm{var}(k\gamma) = \bar{k}^2\,\mathrm{var}(\gamma) + \bar{\gamma}^2\,\mathrm{var}(k) + \mathrm{var}(k)\,\mathrm{var}(\gamma)$*. θ^* is decreasing in $\bar{b}$, ϕ, $\bar{\gamma}$,* $\mathrm{var}(k)$*, and increasing in* $\mathrm{var}(\gamma)$*, $\bar{\rho}_0$, $\bar{\rho}_1$. An increase in $\bar{k}$ has an ambiguous impact on θ^*.*

Since $\bar{b} < 1$ and $\bar{k} > 0$, Eq. (44) shows that $\theta^* > 0$ if and only if $\mathrm{var}(\gamma) > 0$, that is if and only if different individuals suffer different health harms from smoking. For given $\mathrm{var}(\gamma) > 0$, the higher is the marginal cost ϕ of the policy θ, the lower is its optimal level θ^*. Notice also that θ^* is affected neither by market structure (i.e., by n), nor by the average level of the externality, η, nor by the degree of smoking restrictions, r.

That the optimal tax rate $t^*(\theta, r)$ is an increasing function of the average health harm, $\bar{\gamma}$, while the optimal control policy θ^* is increasing in its variance, $\mathrm{var}(\gamma)$, is easily explained by looking at the partial derivatives (11) and (12), representing the impact of t and θ on individual consumption, respectively. While $\partial x^*/\partial\theta$ is a decreasing function of γ, $\partial x^*/\partial t$ is independent of it. Moreover, in expected terms, $\mathrm{E}_F[\partial x^*/\partial\theta] = \bar{k}\bar{\gamma}\,\mathrm{E}_F[\partial x^*/\partial t]$. The latter equation implies that t and θ are equivalent instruments for targeting the average level of the internality, $(1-\bar{\beta})\bar{\gamma}$. Therefore, since θ is costly (provided that $\phi > 0$) whereas t is costless, only the latter instrument is used to correct for the average level of the internality. The policy θ then turns out to be a useful additional instrument insofar individual health harms have a positive variance, since θ bears a different impact on individual tobacco demands for different values of γ.

Notice also that θ^* is a decreasing function of $\text{var}(k)$, whereas the impact of $\bar{k}$ is undecided. A higher $\text{var}(k)$ implies that policy θ is less accurate in targeting the various types of smokers, since prevention programs impact differently on different smokers, and therefore its optimal level θ^* is lower. A higher $\bar{k}$, instead, implies that policy θ is on average more effective in discouraging tobacco overconsumption, and therefore it lowers its optimal level θ^*. However, a higher $\bar{k}$ also increases $\text{var}(k\gamma)$ and this tends to reduce θ^*. Eq. (44) also shows that θ^* is a decreasing function of $\bar{b}$, the average level of the exogenous component of β.

By substituting for θ^* from Eq. (44) into $t^*(\theta, r)$ shown in Eq. (36), we get the optimal tax rate $t^*(\theta^*, r)$ as a function of the policy instrument r. It is immediate to see that $1-\bar{\beta}(\theta^*) = 1-\bar{b}-\bar{k}\theta^* > 0$, which means that the first term of the optimal tax rate, i.e., the one correcting for time inconsistent smoking behavior, is always positive when θ is optimally set.[18] This further clarifies the interpretation of Propositions 2 and 3. In particular, it is instructive to consider the special case in which θ is costless ($\phi = 0$), with $\text{var}(k) = 0$ and $\text{var}(\gamma) > 0$. From Eqs. (36) and (44) we then see that $\theta^* = (1-\bar{b})/\bar{k}$, which implies that the first term of $t^*(\theta^*, r)$ is zero. That is, each instrument targets a different source of market failure: while taxation corrects for the consumption externality and oligopoly pricing, prevention programs correct for the consumption internality. Note that policy θ is always zero at the optimum when $\text{var}(\gamma) = 0$ and $\phi > 0$, because in this case taxation, which is costless, is a sufficient instrument to target all sources of market failure.

Finally, before turning to the determination of the level of smoking restrictions r, we notice that the optimal policies, θ^* and $t^*(\theta^*, r)$, represent the unique maximum of the policy problem, since the welfare function (31) is a strictly concave function of the variables (t, θ) — as shown in Appendix A.2.

[18] Clearly, that $\bar{\beta}(\theta^*) = \bar{b} + \bar{k}\theta^* < 1$ does not imply that $\beta(\theta^*) = b + k\theta^* < 1$ for all (b, k). That is, for some smokers, it could be that $\beta(\theta^*) > 1$, which means that the policy θ^* causes tobacco underconsumption.

4.3 Smoking restrictions

We study the choice of the optimal level of smoking restrictions by focusing on the first order partial derivative of the objective function (31) with respect to r; i.e.,

$$\frac{1}{m}\frac{\partial \Omega^*}{\partial r} = \mathrm{E}_F\left[\frac{\partial u^*}{\partial r} - (1-\beta)\gamma\frac{\partial x^*}{\partial r} + x^*\frac{\partial p^*}{\partial r} + (p^*-c)\frac{\partial x^*}{\partial r}\right] - \frac{\partial \Gamma^*}{\partial r}. \tag{45}$$

Using Eqs. (27), (13), (16), (34), and the fact that Eq. (22) can be written as

$$\frac{\partial \Gamma^*}{\partial r} = \alpha\bar{\xi}\frac{\partial \Gamma^*}{\partial t} - \frac{1+n}{n}\alpha\bar{\xi}\frac{\partial \Gamma^*}{\partial t} - 2\alpha\eta_0(1-r)X^{*\mathrm{u}}, \tag{46}$$

the derivative in Eq. (45) can be expressed as

$$\frac{1}{m}\frac{\partial \Omega^*}{\partial r} = -\alpha\mathrm{E}_F\left[v^{\mathrm{u}}(x^{*\mathrm{u}}) - v^{\mathrm{r}}(x^{*\mathrm{r}})\right] + \alpha\bar{\xi}\frac{1}{m}\frac{\partial \Omega^*}{\partial t} + \frac{1+n}{n}\alpha\bar{\xi}\frac{\partial \Gamma^*}{\partial t} + 2\alpha\eta_0(1-r)X^{*\mathrm{u}}. \tag{47}$$

With t optimally set, the second term of the above derivative is zero. The remaining terms of Eq. (47) can conveniently be interpreted in terms of the marginal costs and marginal benefits involved in the optimal choice of r.

Given that $x^{*\mathrm{u}} - x^{*\mathrm{r}} = \rho_0\rho_1\xi > 0$ by Eq. (3), from the definition of the utility function given in Eq. (1), we can compute the expected value of the first term in Eq. (47) as being equal to

$$\begin{aligned} -\alpha\mathrm{E}_F\left[v^{\mathrm{u}}(x^{*\mathrm{u}}) - v^{\mathrm{r}}(x^{*\mathrm{r}})\right] &= -\alpha\mathrm{E}_F\left[\rho_0\xi\left(1 - \frac{\rho_1\xi}{2}\right)\right] = \\ &= -\alpha\bar{\rho}_0\left(\bar{\xi} - \frac{1}{2}\bar{\rho}_1(\mathrm{var}(\xi) + \bar{\xi}^2)\right) < 0, \end{aligned} \tag{48}$$

which is strictly negative for $\xi > 0$, since the assumption that $x^{*\mathrm{r}} = \rho_0(1-\rho_1\xi) - \rho_0\rho_1(\beta\gamma + p^*) > 0$ implies $1 - \rho_1\xi > 0$ and therefore also $1 - \rho_1\xi/2 > 0$, for all (ρ_1, ξ). The expressions shown in Eq. (48) represent the average marginal welfare cost (in terms of reduced hedonic pleasure for complying with smoking restrictions) that smokers bear when, by increasing r, smoking is forbidden in more locations. Note that this marginal welfare cost is independent of r and of the other policy instruments, t and θ.

Using Eq. (20), the third term of Eq. (47) can be written as

$$\frac{1+n}{n}\alpha\bar{\xi}\frac{\partial \Gamma^*}{\partial t} = -\bar{\xi}\bar{\rho}_0\bar{\rho}_1\eta_0\alpha^2(1-r)^2 \leq 0. \tag{49}$$

This term represents the welfare cost due to the fact that an increase in r, by lowering the equilibrium price p^*, tends to increase tobacco consumption and therefore also the externality Γ^* in unrestricted locations.

Overall, the marginal costs involved in the choice of r are defined by (minus) the sum of the terms in Eqs. (48) and (49):

$$\mathrm{MC}(r) = \bar{\xi}\bar{\rho}_0\bar{\rho}_1\eta_0\alpha^2(1-r)^2 + \alpha\bar{\rho}_0\left(\bar{\xi} - \frac{1}{2}\bar{\rho}_1(\mathrm{var}(\xi) + \bar{\xi}^2)\right). \tag{50}$$

The marginal benefits of increasing r are instead defined by the fourth term in Eq. (47), which accounts for the benefits of stricter regulation in terms of externality abatement. By substituting for the optimal tax rate $t^*(\theta, r)$ defined in Eq. (36) into $X^{*\mathrm{u}}$, we have that marginal benefits are equal to

$$\mathrm{MB}(r) = 2\alpha\eta_0(1-r)\left. X^{*\mathrm{u}}\right|_{t=t^*(\theta,r)}, \tag{51}$$

where

$$\left. X^{*\mathrm{u}}\right|_{t=t^*(\theta,r)} = \bar{\rho}_0 - \bar{\rho}_0\bar{\rho}_1\left(c + \bar{\gamma} + \frac{n}{1+n}\alpha\eta_0(1-r)^2\right). \tag{52}$$

Note that the marginal benefits of regulation r, which are evaluated with taxation set at its optimal level $t^*(\theta, r)$, do not depend on the level of prevention policies θ. Notice also that, with t optimally set, the marginal benefits of stricter regulation do not include any welfare gain from health harm abatement. The reason is that, as we have shown above, taxation is a sufficient instrument to target the average health harm per unit of tobacco consumption. No additional gains can be obtained by means of regulation, once taxation is optimally set. Regulation is instead useful to complement taxation in targeting the externality. The problem with taxation is that it is an imperfect instrument for externality abatement, since it reduces consumption both in the externality and in the non-externality generating locations. Regulation, instead, targets tobacco consumption in the externality generating locations only.

By combining Eqs. (50) and (51), the partial derivative of aggregate surplus with respect to the level of smoking restrictions r, with t optimally set, can be expressed as

$$\left.\frac{1}{m}\frac{\partial\Omega^*}{\partial r}\right|_{t=t^*(\theta,r)} = \mathrm{MB}(r) - \mathrm{MC}(r). \tag{53}$$

The following lemma (the proof of which is in Appendix A.3) illustrates the properties of the marginal benefits and cost functions $\mathrm{MB}(r)$ and $\mathrm{MC}(r)$.

Lemma 1 *For $\eta_0 > 0$, the marginal benefits function (51) is a strictly concave function of r, with $\mathrm{MB}(0) > 0$, $\mathrm{MB}(1) = 0$. For $\eta_0 > 0$, $\bar{\xi} > 0$, the marginal costs function (50) is a strictly convex, monotonically decreasing, function of r, with $\mathrm{MC}(0) > \mathrm{MC}(1) > 0$.*

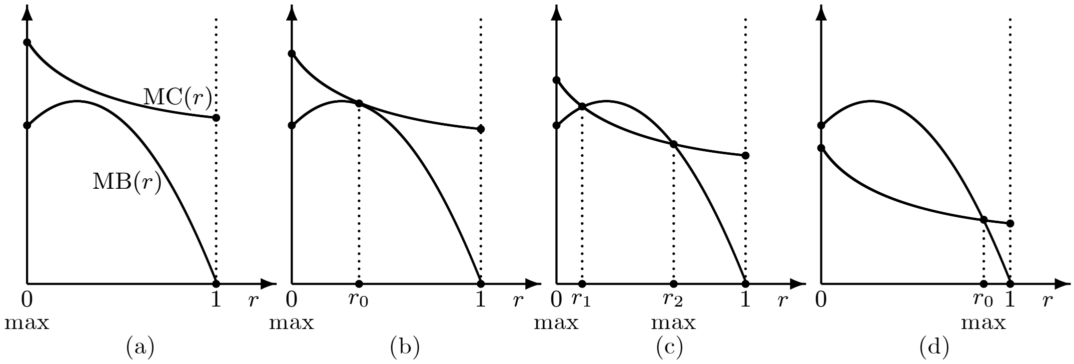

Figure 1: Proof of Proposition 4

The existence of an optimal level of r is characterized in the following proposition, the proof of which is useful in illustrating the logic underlying the use of smoking restrictions.

Proposition 4 *For $t = t^*(\theta, r)$, there always exists an optimal level r^* of smoking restrictions, with $r^* \in [0, 1)$, that maximizes the surplus function (31).*

Proof. Recall that, by Lemma 1, (i) $\mathrm{MB}(r)$ is strictly concave, (ii) $\mathrm{MC}(r)$ is strictly convex, monotonically decreasing, (iii) $\mathrm{MB}(0) \gtreqless \mathrm{MC}(0)$, with $\mathrm{MB}(0) > 0$, $\mathrm{MC}(0) > 0$, (iv) $\mathrm{MC}(1) > \mathrm{MB}(1) = 0$. Given these properties, for any given specification of the relevant parameters, either one of the following outcomes occurs. See panels (a)–(d) in Figure 1 for an illustration.

(a) If $\mathrm{MB}(r) < \mathrm{MC}(r)$ for all $r \in [0, 1]$, then there exists a unique maximum for $r = 0$.

(b) If $\mathrm{MB}(r) = \mathrm{MC}(r)$ for $r = r_0 \in (0, 1)$ and $\mathrm{MB}(r) < \mathrm{MC}(r)$ for all $r \in [0, r_0) \cup (r_0, 1]$, then there exists a unique maximum for $r = 0$.

(c) If (i) $\mathrm{MB}(r) = \mathrm{MC}(r)$ for $r = \{r_1, r_2\}$, $0 < r_1 < r_2 < 1$, (ii) $\mathrm{MB}(r) < \mathrm{MC}(r)$ for all $r \in [0, r_1) \cup (r_2, 1]$, (iii) $\mathrm{MB}(r) > \mathrm{MC}(r)$ for all $r \in (r_1, r_2)$, then there exist two local maxima, one for $r = 0$ and one for $r = r_2 \in (0, 1)$.

(d) If $\mathrm{MB}(0) \geq \mathrm{MC}(0)$, then there exists a unique $r_0 \in (0, 1)$ such that $\mathrm{MB}(r) = \mathrm{MC}(r)$ for $r = r_0$, $\mathrm{MB}(r) > \mathrm{MC}(r)$ for all $r \in (0, r_0)$ and $\mathrm{MB}(r) < \mathrm{MC}(r)$ for all $r \in (r_0, 1]$. Therefore there exists a unique maximum for $r = r_0 \in (0, 1)$. ■

The proposition shows that it is optimal to set a positive degree of regulation whenever the ensuing benefits in terms of externality abatement are, on average, sufficiently higher than the costs imposed, on average, on smokers to comply with the ban. In these cases, as already noted, (incomplete) regulation usefully complements

	$\bar{\rho}_0$	$\bar{\rho}_1$	$\bar{\xi}$	var(ξ)	α	η_0	$\bar{\gamma}$	n
MC(r)	$\uparrow$	$\uparrow\downarrow$	$\uparrow$	$\downarrow$	$\uparrow$	$\uparrow$	–	–
MB(r)	$\uparrow$	$\downarrow$	–	–	$\uparrow\downarrow$	$\uparrow\downarrow$	$\downarrow$	$\downarrow$
$r^* \in (0,1)$	$\uparrow\downarrow$	$\uparrow\downarrow$	$\downarrow$	$\uparrow$	$\uparrow\downarrow$	$\uparrow\downarrow$	$\downarrow$	$\downarrow$

Table 1: Optimal regulation: comparative statics.

taxation by banning tobacco use only where it causes external costs that are relatively large. This means, however, that the smoking bans discussed here are only able to achieve second best allocations, as they impose zero consumption in restricted locations (where the externalities are relatively large) and free consumption in the unrestricted ones (where the external costs are relatively small), rather than reducing consumption to its first-best level given the magnitude of external costs.

The factors impacting on the marginal costs and benefits functions (50) and (51) are summarized in Table 1. Limiting the analysis to the case in which the optimal degree of regulation r^* belongs to an interior point of its feasible range, Table 1 shows that an increase in the average cost $\bar{\xi}$ suffered by smokers for complying with smoking bans — by increasing the marginal costs of regulation — reduces its optimal level, whereas an increase in their variance var(ξ) has the opposite effect. Recalling from Proposition 2 that $t^*(\theta, r)$ is increasing in $\bar{\xi}$, we then see that while an increase in $\bar{\xi}$ calls for weaker regulation and higher taxation at the optimum, an increase in var(ξ) calls for stricter regulation without affecting the optimal tax. By reducing the marginal benefits of regulation, an increase in the average health harm $\bar{\gamma}$ reduces the optimal degree of regulation; the reason is that higher health harms are already optimally handled with higher taxation, so that the reduction in tobacco consumption allows for weaker regulation. A similar outcome emerges as the market becomes more competitive, since an increase in the number n of tobacco producers calls for higher taxation and weaker regulation at the optimum. The parameters $\bar{\rho}_0$, $\bar{\rho}_1$, α and η_0 bear instead an ambiguous impact on r^*, since they affect both the marginal costs and benefits in ways that may push r^* towards opposite directions. Which of the effects prevails depends on the specific parameters constellation considered. Notice finally that the marginal costs and benefits of r are independent of $\bar{b}$, $\bar{k}$, var(γ), var(k) and ϕ. These parameters, which are relevant in the determination of the optimal tax and prevention policies, are irrelevant in the determination of the optimal degree of smoking restrictions. The following proposition summarizes the results on the comparative statics of the optimal degree of regulation illustrated in Table 1.[19]

Proposition 5 *If* $r^* \in (0,1)$*, then* r^* *is increasing in* $\mathrm{var}(\xi)$ *and decreasing in* $\bar{\xi}$*,* $\bar{\gamma}$ *and* n*. An increase in* $\bar{\rho}_0$*,* $\bar{\rho}_1$*,* α *or* η_0 *has an ambiguous impact on* r^**.*

4.4 The efficient set of policies

The results on the characterization of efficient policy instruments derived in Propositions 2, 3 and 4 are summarized in Proposition 6.

Proposition 6 *A benevolent policy maker maximizing the aggregate surplus defined in Eq. (31) sets the policy instruments* t^**,* θ^**, and* r^* *such that:*

- *the optimal level of prevention policy,* θ^**, is defined in Eq. (44);*
- *the optimal level of smoking restrictions,* r^**, is either* $r^* = 0$ *or* $r^* \in (0,1)$*. Full regulation, i.e.,* $r^* = 1$*, is never optimal.*
- *the optimal tax rate is* $t^*(\theta^*, r^*)$*, with* $t^*(\theta, r)$ *defined in Eq. (36).*

In the same way, Table 2 summarizes the comparative statics results concerning the socially optimal set of policy instruments derived in Propositions 2, 3 and 5. Note that some of the model parameters affect the optimal tax rate both *directly*, since they enter the expression for $t^*(\theta, r)$ defined in Eq. (36), and *indirectly*, since they affect the optimal levels of prevention policies θ^* and regulation r^*, which in turn affect the tax rate t^*. While all direct effects are unambiguous, the impact of some parameters on the optimal tax rate can be either positive or negative because of the indirect effects. For instance, an increase in $\bar{b}$ directly reduces the optimal tax rate but, since it also reduces the optimal level of prevention policies, it indirectly increases t^*.

[19] The results in Proposition 5 and Table 1 follow immediately from differentiation of Eqs. (50) and (51) with respect to the relevant parameters. That $\partial \mathrm{MC}(r)/\partial\bar{\xi} = 1 - \bar{\rho}_1\bar{\xi} > 0$ follows from the fact that $x^{*r} > 0$ for all smokers by assumption (see the discussion following Eq. 48).

	direct effects													indirect effects	
	$\bar{\rho}_0$	$\bar{\rho}_1$	$\bar{\xi}$	$\mathrm{var}(\xi)$	$\bar{b}$	$\bar{k}$	$\mathrm{var}(k)$	$\bar{\gamma}$	$\mathrm{var}(\gamma)$	ϕ	α	η_0	n	θ	r
$r^* \in (0,1)$	↑↓	↑↓	↓	↑	–	–	–	↓	–	–	↑↓	↑↓	↓	.	.
θ^*	↑	↑	–	–	↓	↑↓	↓	↓	↑	↓	–	–	–	.	.
$t^*(\theta, r)$	–	↑	↑	–	↓	↓	–	↑	–	–	↑	↑	↑	↓	↑↓

Table 2: Socially efficient policies: comparative statics.

5 Lobbying

In our economy, there are three types of agents that are affected by tobacco control policies: producers, smokers, and non-smokers. In this section, we examine whether and how they can influence public policies by means of organized lobby groups, who are delegated by individual economic agents the task of pursuing their views (e.g., lobby firms, or non governmental organizations). We do not model how groups are formed and how lobbying decisions are taken within them. We simply assume the existence of a distinct lobby group for each one of the categories involved — producers, smokers, and non-smokers — and endow them with a well defined objective function, obtained by aggregation of the payoff functions of its members.[20]

We model lobbying behavior using the so-called 'buying influence' approach, developed in the context of common-agency games with perfect information by Dixit *et al.* (1997) and Grossman and Helpman (1994, 2001), building on previous work by Bernheim and Whinston (1986a, 1986b). In this framework, interest groups compete by offering monetary rewards to the policy maker conditional on the types of policies implemented (in the form, for instance, of campaign contributions), which are both legal and public.

Formally, the lobbying game evolves along two stages and is solved backward using the notion of subgame perfection. In the first stage, the interest groups (the principals)

[20] Note that in the real world also tobacco producers, although competing in the market for their products, often coordinate their lobbying activities by means of a lobby firm representing their collective interests.

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present to the policy maker a menu of offers (i.e., a series of contributions), each one associated to a given set of policies. Upon acceptance of the offers, the policy maker picks her preferred choice in the second stage of the game. With this type of common agency games, it is analytically convenient to focus on *truthful*, or *compensating*, contribution functions of the type defined by Dixit *et al.* (1997). The feature of a truthful contribution function is that of being shaped along an indifference curve of the lobby group, so that any given change in a policy instrument brings about a corresponding change in the contribution that is equal to the variation in the payoff of the group making the offer. A nice property of truthful contributions is that the set of the best responses of each principal to the contribution functions (not necessarily truthful) of the other principals always contains a truthful contribution schedule (Dixit *et al.*, 1997, proposition 2). Hence, compensating contributions functions solve also the problem of equilibrium selection, since common agency games typically have multiple equilibria.

To define the contribution functions of the lobby groups, we therefore need first to characterize their payoff functions. As for producers, their payoff is simply given by their aggregate profits defined in Eq. (30). As for tobacco consumers, we assume that *smokers-as-a-group* have policy preferences that are less biased than those prevailing (on average) at the individual level, while not necessarily fully reflecting their unbiased welfare measure. Hence, we assume that smokers evaluate policy outcomes by means of a convex linear combination of their 'true' surplus, $m\mathrm{E}_F[w^*]$, with w^* defined in Eq. (23), and their 'biased' surplus

$$m\mathrm{E}_F[w^*] + m\left\{\mathrm{E}_F[(1-\beta)\gamma x^*] + m\Gamma^*\right\}. \tag{54}$$

As Eq. (54) shows, such a welfare measure is biased because it corresponds to the aggregate measure of the utility functions describing smokers' effective behavior, which reflects both the lack of self control and the failure to account for the external costs of smoking. Letting $\lambda \in [0, 1]$ be the weight given to the biased component defined in Eq. (54), the objective function of smokers as a lobby group can be defined as

$$S^* = m\mathrm{E}_F[w^*] + \lambda m\left\{\mathrm{E}_F[(1-\beta)\gamma x^*] + m\Gamma^*\right\}. \tag{55}$$

Turning finally to non-smokers, their surplus function (defined in Eq. (28)) shows that they care for policies that raise tax revenue from tobacco consumption — since they cash part of it as a subsidy — and that contribute to the abatement of the external costs of smoking — since they are harmed by passive smoking. However, it is well known that citizens' anti-tobacco movements do not generally pursue only 'selfish' goals but also 'altruistic' ones, such as improving the health prospects of smokers (especially the young ones).[21] The latter observation suggests that a realistic specification of the objective function for the group of non-smokers can be given by their own surplus function, defined in Eq. (28), augmented by an additional term accounting for the welfare costs due to tobacco consumption that smokers fail to internalize into their objective function (55). Specifically, we define the payoff function of *non-smokers-as-a-group* as

$$Z^* = (1-m)\tilde{w} - a\lambda m \left\{ \mathrm{E}_F \left[(1-\beta)\gamma x^* \right] + m\Gamma^* \right\}, \tag{56}$$

where $a \in [0,1]$ is a parameter expressing the degree of altruism of the group. The payoff function defined in Eq. (56) implies that the group of non-smokers favors policies that reduce the external and the internal costs of smoking, and that maximize tax revenue. Note that the latter goal does not conflict with those aimed at discouraging tobacco consumption, unless the equilibrium tax policy is located on the decreasing side of the Laffer curve.

Using the objective functions defined above, the truthful contributions offered by firms (f), smokers (s) and non-smokers (ns), are

$$C^{\mathrm{f}}(t,\theta,r;\varpi^{\mathrm{f}}) = \delta^{\mathrm{f}} \max \left\{ 0, m\Pi^*(t,\theta,r) - \varpi^{\mathrm{f}} \right\}, \tag{57}$$

$$C^{\mathrm{s}}(t,\theta,r;\varpi^{\mathrm{s}}) = \delta^{\mathrm{c}} \max \left\{ 0, S^*(t,\theta,r) - \varpi^{\mathrm{s}} \right\}, \tag{58}$$

$$C^{\mathrm{ns}}(t,\theta,r;\varpi^{\mathrm{ns}}) = \delta^{\mathrm{c}} \max \left\{ 0, Z^*(t,\theta,r) - \varpi^{\mathrm{ns}} \right\}, \tag{59}$$

respectively, where ϖ^{f}, ϖ^{s} and ϖ^{ns} are non-negative scalars representing the net payoff of the lobby group. The parameters $\delta^{\mathrm{f}} \in [0,1]$ for firms and $\delta^{\mathrm{c}} \in [0,1]$ for both smokers and non-smokers (where the superscript 'c' stands for 'citizens') capture, in a reduced form, how effective the groups are in their lobbying activity. When $\delta^{\mathrm{i}} = 1$, $\mathrm{i} = \{\mathrm{f}, \mathrm{c}\}$, the corresponding group is fully powerful in lobbying, while when $\delta^{\mathrm{i}} = 0$ it does not lobby at all (say, because of free-riding of its potential members). The assumption of a

[21] To illustrate the point, consider the stated purposes of two US based anti-smoking organizations. *Action on Smoking and Health* (www.ash.org) "envisions a world free of tobacco-related damage, disease and death. This is accomplished by taking action to educate the public and decision makers, track the tobacco industry, and work for sensible public policies." The *Campaign for Tobacco-Free Kids* organization (www.tobaccofreekids.org) "advocates for public policies proven to prevent kids from smoking, help smokers quit and protect everyone from second-hand smoke."

common parameter $\delta^{\rm c}$ for smokers and non-smokers is an analytically convenient one that embraces the neutral view that the two groups are equally active in lobbying, since there is no compelling empirical evidence about their relative strengths. As tax revenue is uniformly rebated to smokers and non-smokers, and not to producers, the assumption of equally powerful groups also implies that the impact of policy instruments on tax revenue is irrelevant for the lobbying incentives of citizens.

Given the contribution functions (57)–(59), the objective function of the policy maker is

$$\Omega^* + C^{\rm f}(t,\theta,r;\varpi^{\rm f}) + C^{\rm s}(t,\theta,r;\varpi^{\rm s}) + C^{\rm ns}(t,\theta,r;\varpi^{\rm ns}), \tag{60}$$

where Ω^* is the per capita surplus defined in Eq. (31).

Focusing on the second stage of the lobbying game, policy choices under the influence of lobbying can be derived by maximizing[22]

$$V^* = \Omega^* + \delta^{\rm f} m\Pi^* + \delta^{\rm c} S^* + \delta^{\rm c} Z^*. \tag{61}$$

Taking into account that

$$\Omega^* = m\mathrm{E}_F\left[w^*\right] + (1-m)\tilde{w} + m\Pi^*,$$

and substituting for S^* from Eq. (55) and for Z^* from Eq. (56), after some manipulations the objective function (61) can be expressed as

$$V^{**} = \frac{V^*}{1+\delta^{\rm c}} = \Omega^* + \mu_1 m\left\{\mathrm{E}_F\left[(1-\beta)\gamma x^*\right] + m\Gamma^*\right\} + \mu_2 m\Pi^*, \tag{62}$$

where

$$\mu_1 = \frac{\delta^{\rm c}(1-a)\lambda}{1+\delta^{\rm c}} \in \left[0,\frac{1}{2}\right], \qquad \mu_2 = \frac{\delta^{\rm f}-\delta^{\rm c}}{1+\delta^{\rm c}} \in \left[-\frac{1}{2},1\right]. \tag{63}$$

Eq. (62) highlights that there are two channels by which lobbying can distort the choices of the policy maker away from the maximization of the economy's aggregate surplus Ω^*. The first, which is expressed by the weight μ_1, is due to smokers' pressure

[22] We ignore the non-negativity constraints on the contribution functions. After solving for the second stage of the game by maximizing Eq. (61) with respect to the policy instruments, one can solve for the Nash equilibrium at the first stage in the scalars $\varpi^{\rm f}$, $\varpi^{\rm s}$ and $\varpi^{\rm ns}$, and then check that the solution implies positive contributions in equilibrium. However, we solve only for the second stage, since we are interested only in the distorting impact of lobbying, and not on its distributional consequences among the interested parties.

for relaxing policies directed at reducing the external and the internal costs of tobacco consumption. This term, which is directly related to the measure, λ, of the bias of smokers' policy preferences, is counterbalanced by the altruistic efforts of non-smokers, as expressed by the index a. The distortion coming from smokers' lobbying is maximal when $\lambda = 1$ and $a = 0$, whereas it is nil when $a = 1$, no matter the value of λ. Note that lobbying by tobacco producers does not distort policies directed at reducing the external and the internal costs of smoking, since the weight μ_1 does not depend on δ^{f}.

The second possible source of distortion shown in Eq. (62) is due to the conflicting policy preferences of smokers and producers about profits. While the former favor policies that reduce the profits of tobacco producers since this implies lower cigarettes prices, the latter obviously make political pressure for policies that increase them. The conflict between the two groups is captured by the lobbying weight μ_2, which shows that lobbying biases policies in favor of higher profits when tobacco producers are more powerful lobbyists than smokers, i.e., when $\delta^{\mathrm{f}} > \delta^{\mathrm{c}}$, while the bias is in the opposite direction if smokers are more powerful than producers.

In order to guarantee that the objective function (62) is concave in the policy instruments (t, θ), we let (see Appendix A.4)

$$n - 2\mu_2 > 0 \qquad \text{and} \qquad \frac{\phi}{\bar{\rho}_0 \bar{\rho}_1} > \frac{n\mu_1^2}{n - 2\mu_2}(\bar{k}\bar{\gamma})^2 - (1 - 2\mu_1)\mathrm{var}(k\gamma). \tag{64}$$

Note that the first condition in Eq. (64) holds true for all admissible values of μ_2 if $n \geq 3$, while it requires only that $\mu_2 < 1$ if $n = 2$. Hence, for all market structures but for the monopoly case, the condition is typically satisfied. The second condition requires instead that the slope of the marginal cost of prevention policies, ϕ, is greater than a given threshold that is increasing in the lobbying weights μ_1 and μ_2. Hence, overall, the conditions in (64) introduce fairly weak restrictions.

The equilibrium tobacco control policies in the presence of lobbying are obtained by maximizing Eq. (62) with respect to the policy instruments, leading to the following proposition the proof of which is given in Appendix A.5.

Proposition 7 *In the presence of lobbying, under the conditions in (64) and focusing on internal solutions, the following statements hold true.*

- *For given θ and r, the equilibrium tax rate is equal to*

$$t^{**}(\theta, r) = \left(1 - \frac{(1+n)\mu_1}{n - 2\mu_2}\right)\left[(1 - \bar{\beta}(\theta))\bar{\gamma} + \alpha\eta_0(1-r)^2\right] - \frac{1 + 2\mu_2}{n - 2\mu_2}\Psi(r), \tag{65}$$

where $\Psi(r) > 0$ is defined in Eq. (37). $t^{**}(\theta, r)$ is decreasing in μ_1 and μ_2.

- *For given r, the equilibrium level of prevention policies, $\theta^{**}(r)$, is defined by the solution in θ of*

$$\theta = \frac{(1-\mu_1)(1-\bar{b})\bar{k}\,\mathrm{var}(\gamma) - \mu_1 \mathrm{E}_F\left[k\gamma x^*(t^{**}(\theta,r),\theta,r)\right]/(\bar{\rho}_0\bar{\rho}_1)}{\phi/(\bar{\rho}_0\bar{\rho}_1) + (1-\mu_1)\mathrm{var}(k\gamma)}. \quad (66)$$

  $\theta^{**}(r)$ is decreasing in μ_1 and μ_2.

- *The equilibrium level of smoking bans, r^{**}, is defined by the solution in r of*

$$2\alpha\eta_0(1-r)\left.X^{*\mathrm{u}}\right|_{t=t^{**}(\theta^{**}(r),r)} = \bar{\xi}\bar{\rho}_0\bar{\rho}_1\eta_0\alpha^2(1-r)^2 + \frac{\alpha\bar{\rho}_0\left(\bar{\xi} - \frac{1}{2}\bar{\rho}_1(\mathrm{var}(\xi)+\bar{\xi}^2)\right)}{1-\mu_1}. \quad (67)$$

  r^{**} is decreasing in μ_1.

- *The equilibrium level of θ is given by $\theta^{**}(r^{**})$ and that of t by $t^{**}(\theta^{**}(r^{**}), r^{**})$.*

In the special case in which $\delta^{\mathrm{c}} = \delta^{\mathrm{f}}$ — meaning that all groups are equally effective in lobbying — and $\lambda = 0$, or $a = 1$ — meaning that either smokers *as a lobbying group* have unbiased policy preferences, or non-smokers *as a lobbying group* are fully altruistic (while smokers may have biased policy preferences) — the three groups end up perfectly balancing each other (since $\mu_1 = \mu_2 = 0$) and lobbying is completely ineffective. In all other cases, lobbying is instead capable of distorting public policy.

It is convenient to illustrate the results of Proposition 7 by considering first the impact of lobbying on the equilibrium level of smoking restrictions, and then on that of prevention policies and taxation. Eq. (67) shows that an increase in the lobbying weight μ_1, by increasing the marginal costs of smoking restrictions, distorts downward their equilibrium level r^{**}. As noted above, the value of μ_1 expresses the conflicting pressures on policy by smokers on the one side and non-smokers on the other. Whenever citizens are active in lobbying (i.e., $\delta^{\mathrm{c}} > 0$), and smokers have biased policy preferences (i.e., $\lambda > 0$), then $\mu_1 > 0$ and the level of smoking restrictions is distorted downward by lobbying unless non-smokers are fully altruistic (i.e., $a = 1$), in which case $\mu_1 = 0$ and smoking restrictions are set at their efficient level. Note finally that producers do not target smoking restrictions, since r^{**} does not depend on μ_2. The reason is that the impact of r on profits is isomorphic to that of taxation (see Eqs. (14) and (16)). Hence, once producers lobby for lower taxation (as argued below), it becomes redundant for them to pressure also for weaker regulation.

Turning to prevention policies, note that lobbying exerts both direct effects — which are expressed by the impact of the lobbying weights (μ_1, μ_2) on θ^{**} for given r — and indirect effects — which are channeled by the impact of lobbying on the equilibrium level of smoking restrictions, r^{**}, illustrated above. Focusing our attention on direct effects only, Eq. (66) in Proposition 7 implies that $\theta^{**}(r)$ is a decreasing function of both lobbying weights (μ_1, μ_2). However, it also shows that while μ_1 affects the right hand side of Eq. (66) both directly and indirectly through its impact on the equilibrium tax rate $t^{**}(.)$, the weight μ_2 exerts only an indirect impact through $t^{**}(.)$. This means that the weight μ_1 is key for understanding the impact of lobbying on prevention policies. Hence, as for smoking restrictions, the impact of lobbying on prevention policies crucially depends on the conflicting pressures of smokers and non-smokers. In the case of prevention programs, however, also producers' lobbying is relevant, but only insofar as their political pressure, by impacting on the equilibrium tax rate, also indirectly impacts on prevention programs.

Turning finally to taxation, Eq. (65) in Proposition 7 highlights that lobbying directly targets in a distinctive manner two components of the equilibrium tax rate, namely (i) the Pigouvian corrections for the average component of the health harm not internalized by smokers because of their lack of self control and for the average externality (since smoking restrictions are never maximal in equilibrium), and (ii) the subsidy term correcting for the market power of tobacco producers. Eq. (65) shows that the Pigouvian-tax component is distorted downward by lobbying if $\mu_1 > 0$, that is if citizens are active in lobbying (i.e., $\delta^{c} > 0$) and smokers have biased policy preferences while non-smokers are not fully altruistic (i.e., $\lambda > 0$ and $a < 1$). Note also that the distortion is larger the greater is μ_2, that is the more effective are firms in lobbying compared to citizens. If instead non-smokers are fully altruistic (i.e., $a = 1$), then smokers' and non-smokers' lobbying efforts perfectly balance and they are ineffective in distorting the Pigouvian component of taxation. As for the subsidy term, Eq. (65) shows that the distortion depends on the weight μ_2, that is on the relative strength in lobbying of tobacco producers and smokers. Since higher profits benefit firms but they harm consumers, the former lobby for a more generous subsidy while the latter call for reducing it.

6 Concluding remarks

This paper investigates the optimal design of policies controlling the consumption of tobacco based on the joint use of three instruments: excise taxes, prevention programs and smoking bans.

We find that prevention policies and smoking restrictions can usefully complement taxation in controlling tobacco consumption. While taxes can correct the average externalities and internalities induced by smoking, the other two policy instruments address the heterogeneity within the group of smokers. Furthermore, smoking restrictions also help curbing externalities that are only partially corrected by uniform taxation, as the latter can not properly account for the externalities imposed by smokers in different environments.

Lobbying by tobacco firms, smokers and non-smokers is shown to target different objectives. In equilibrium, producers mainly focus on reducing tobacco taxation, while consumers' lobbying (by both smokers and non-smokers) affect prevention policies and regulation in ways that depend on the intensity of their preferences.

The paper can be extended along several dimensions. While our analysis combines three major policy instruments for controlling tobacco consumption, additional more specific measures have been neglected, such as restrictions and bans on advertising of tobacco products, or regulatory policies that target specific groups of individuals, like youth access laws. Moreover, firms may combine lobbying of the policy maker with activities aimed at directly affecting consumers' choices, such as information campaigns aimed at counteracting public prevention programs. The introduction of these additional features into the analysis is a line of research to be pursued in the future.

In our model, an exogenous share of tobacco consumption (represented by the parameter α) occurs in locations in which smoking causes external costs to other individuals. Moreover, we have assumed that smoking restrictions are applicable to all smoking locations in which externalities occur. However, it is clearly possible that smokers react to stricter smoking bans by increasing their smoking in locations where a ban cannot be enforced and in which an externality occurs (e.g. children's second-hand smoking at home). The latter is the issue examined, both theoretically and empirically, by Adda and Cornaglia (2010), and it is clearly one that could further enrich our analysis.

Furthermore, our setting does not deal with the social aspects of smoking — i.e. the fact that smoking habits may ensue from imitation and social interactions, a line of research that has been developed by Cutler and Glaeser (2010) and Sari (2013), among others.

Finally, in our model, tobacco taxation is of the *specific* type. This notwithstanding, in many countries also an *ad valorem* tax is used (in the EU, for instance, both VAT and excises are levied on tobacco and alcoholic products). Since ad valorem and specific taxation are not equivalent in oligopolistic markets (see, e.g. Myles, 1995), it might be interesting to examine the optimal mix between the two types of taxes, and how special interest groups target them.

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Appendix

A.1 Derivation of the utility function

We consider the case in which tobacco consumption occurs in a location that is subject to a smoking ban, where it is assumed that gross surplus is uniformly distributed on the closed interval $[-\xi, 1/\rho_1 - \xi]$, with $0 < \xi < 1/\rho_1$. The case in which smoking occurs in an unrestricted location obtains by simply setting $\xi = 0$.

Denote with $\hat{s} \in [0, 1/\rho_1 - \xi]$ a positive threshold level of the gross surplus. If, within the given period of time, a smoker consumes only those units of x for which $s \geq \hat{s}$, then the expected quantity consumed is equal to:

$$x(\hat{s}) = \int_{\hat{s}}^{1/\rho_1 - \xi} \rho_1 \rho_0 \, \mathrm{d}s = \rho_0 \left(1 - \xi\rho_1 - \hat{s}\rho_1\right). \tag{A.1}$$

Recall that the total gross surplus from smoking is assumed to be equal to the sum of the gross surpluses from the various consumption units (an assumption akin to that of risk neutrality). Hence, the expected total gross surplus associated to the consumption of those units of x for which $s \geq \hat{s}$ is equal to:

$$v(\hat{s}) = \int_{\hat{s}}^{1/\rho_1 - \xi} \rho_1 \rho_0 s \, \mathrm{d}s = \frac{\rho_1 \rho_0}{2} \left(\left(\frac{1}{\rho_1} - \xi \right)^2 - \hat{s}^2 \right). \tag{A.2}$$

Using the other assumptions introduced in Section 3.1 (i.e., the gross surplus of each unit of the *numeraire* good z is equal to one; the perceived present value of future health harm is equal to $\beta\gamma$ for each unit of good x consumed; the consumer is price-taker), we can conclude that the individual will consume only those units of good x for which $s \geq \hat{s} \equiv p + \beta\gamma$. The expected demand of good x is then $x(\hat{s})$, as shown in Eq. (A.1). All income effects fall on the quantity consumed of good z.

The consumer's problem can be expressed in the more familiar form in which the individual chooses her consumption bundle (x, z) by maximizing a utility function subject to a budget constraint, instead of choosing the threshold level of the gross surplus. To express the problem in the latter format, invert Eq. (A.1) to get

$$\hat{s}(x) = \frac{1}{\rho_1} - \xi - \frac{x}{\rho_1 \rho_0},$$

and then substitute $\hat{s}(x)$ into Eq. (A.2) to obtain

$$v(x) = \frac{1}{\rho_1} \left(1 - \xi\rho_1 - \frac{x}{2\rho_0} \right) x. \tag{A.3}$$

Recalling that the utility of good z is linear with unitary slope, and that consumption x^{u} in unrestricted locations ($\xi = 0$) is a share $1 - \alpha r$ of total consumption (while consumption x^{r} in restricted locations ($\xi > 0$) absorbs the remaining share αr), from Eq. (A.3) we finally obtain the utility function shown in Eq. (1).

A final remark is in order. Strictly speaking, Eq. (A.3) represents an *expected* utility function, since it is assumed that the gross surpluses enjoyed from smoking follow a random process. Similarly, the individual demand functions are in expected terms. However, if one focuses on a sufficiently long period of time, the utility and demand functions can be taken as deterministic objects, as it is done throughout in the paper.

A.2 Concavity of Ω^* in (t,θ)

By totally differentiating the first order derivatives shown in Eqs. (34) and (40), it is immediate to see that the aggregate surplus Ω^* is a strictly concave function of (t,θ) for given r. In fact:

$$\frac{\partial^2\Omega^*}{\partial t^2} \equiv m\frac{\partial p^*}{\partial t}\frac{\partial X^*}{\partial t} = -m\left(\frac{n}{1+n}\right)^2 \bar{\rho}_0\bar{\rho}_1 < 0, \tag{A.4}$$

$$\frac{\partial^2\Omega^*}{\partial\theta^2} \equiv m\mathrm{E}_F\left[\left(k\gamma+\frac{\partial p^*}{\partial\theta}\right)\frac{\partial x^*}{\partial\theta}\right] - \phi = \left(\bar{k}\bar{\gamma}\right)^2\frac{\partial^2\Omega^*}{\partial t^2} - m\left[\mathrm{var}(k\gamma)\bar{\rho}_0\bar{\rho}_1+\phi\right] < 0, \tag{A.5}$$

$$\frac{\partial^2\Omega^*}{\partial t\partial\theta} \equiv m\left(\frac{\partial p^*}{\partial\theta}+\bar{k}\bar{\gamma}\right)\frac{\partial X^*}{\partial t} = \bar{k}\bar{\gamma}\frac{\partial^2\Omega^*}{\partial t^2} < 0, \tag{A.6}$$

$$\frac{\partial^2\Omega^*}{\partial t^2}\frac{\partial^2\Omega^*}{\partial\theta^2} - \left(\frac{\partial^2\Omega^*}{\partial t\partial\theta}\right)^2 \equiv -m\frac{\partial^2\Omega^*}{\partial t^2}\left(\bar{\rho}_0\bar{\rho}_1\ \mathrm{var}(k\gamma)+\phi\right) > 0,$$

where for the latter inequality to hold true it is sufficient to assume that either $\mathrm{var}(k\gamma) > 0$ or $\phi > 0$.

A.3 Proof of Lemma 1

From Eq. (51) it is immediate to see that $\mathrm{MB}(0) > 0$ and $\mathrm{MB}(1) = 0$. By differentiating it with respect to r we get

$$\begin{aligned}\frac{\partial \mathrm{MB}(r)}{\partial r} &= 2\alpha\eta_0(1-r)\frac{\partial X^{**\mathrm{u}}}{\partial r} - 2\alpha\eta_0 X^{**\mathrm{u}} = \\ &= 4\alpha^2\bar{\rho}_0\bar{\rho}_1\frac{1+n}{n}\eta_0^2(1-r)^2 - 2\alpha\eta_0 X^{**\mathrm{u}} \gtreqless 0, \\ \frac{\partial^2 \mathrm{MB}(r)}{\partial r^2} &= -10\alpha^2\bar{\rho}_0\bar{\rho}_1\frac{1+n}{n}\eta_0^2(1-r) < 0,\end{aligned}$$

which proves the first part of the lemma.

From Eq. (50), it is immediate to see that $\mathrm{MC}(0) > 0$ and $\mathrm{MC}(1) > 0$. By differentiating it with respect to r we get

$$\begin{aligned}\frac{\partial \mathrm{MC}(r)}{\partial r} &= -\alpha^2\bar{\rho}_0\bar{\rho}_1\bar{\xi}\left(\eta(r)-(1-r)\frac{\partial\eta}{\partial r}\right) = -2\alpha^2\eta_0(1-r)\bar{\rho}_0\bar{\rho}_1\bar{\xi} < 0, \\ \frac{\partial^2 \mathrm{MC}(r)}{\partial r^2} &= 2\alpha^2\bar{\rho}_0\bar{\rho}_1\bar{\xi}\eta_0 > 0,\end{aligned}$$

which completes the proof of the second part of the lemma.

A.4 Concavity of V^* in (t, θ)

By differentiating Eq. (62) with respect to t, we get

$$\frac{\partial V^{**}}{\partial t} = \frac{\partial \Omega^*}{\partial t} + \mu_1 m(1-\bar{\beta})\bar{\gamma}\frac{\partial X^*}{\partial t} + \mu_1 m\frac{\partial \Gamma^*}{\partial t} + \mu_2 m\frac{\partial \Pi^*}{\partial t}, \tag{A.7}$$

where $\partial X^*/\partial t$ and $\partial \Gamma^*/\partial t$, are defined in Eqs. (14) and (33), respectively, and where

$$\frac{\partial \Pi^*}{\partial t} = (p^* - c - t)\frac{\partial X^*}{\partial t} + \left(\frac{\partial p^*}{\partial t} - 1\right)X^* = -\frac{2}{1+n}X^*. \tag{A.8}$$

Using the fact that

$$\frac{\partial^2 X^*}{\partial t^2} = \frac{\partial^2 \Gamma^*}{\partial t^2} = 0, \qquad \frac{\partial^2 \Pi^*}{\partial t^2} = -\frac{2}{1+n}\frac{\partial X^*}{\partial t} = \frac{2n}{(1+n)^2}\bar{\rho}_0\bar{\rho}_1,$$

and using the expression for $\partial^2\Omega^*/\partial t^2$ defined in Eq. (A.4), we get

$$\frac{\partial^2 V^{**}}{\partial t^2} = -m\frac{n}{(1+n)^2}(n-2\mu_2)\bar{\rho}_0\bar{\rho}_1 < 0 \quad \text{iff} \quad n > 2\mu_2. \tag{A.9}$$

By differentiating Eq. (62) with respect to θ, we have

$$\frac{\partial V^{**}}{\partial \theta} = \frac{\partial \Omega^*}{\partial \theta} + \mu_1 m \mathrm{E}_F\left[(1-\beta)\gamma\frac{\partial x^*}{\partial \theta} - k\gamma x^*\right] + \mu_1 m\frac{\partial \Gamma^*}{\partial \theta} + \mu_2 m\frac{\partial \Pi^*}{\partial \theta}, \tag{A.10}$$

where $\partial x^*/\partial \theta$ and $\partial \Gamma^*/\partial \theta$ are defined in Eqs. (12) and (39), respectively, and where

$$\frac{\partial \Pi^*}{\partial \theta} = (p^* - c - t)\frac{\partial X^*}{\partial \theta} + \frac{\partial p^*}{\partial \theta}X^* = \bar{k}\bar{\gamma}\frac{\partial \Pi^*}{\partial t}. \tag{A.11}$$

Using Eq. (A.5) to write

$$\frac{\partial^2 \Omega^*}{\partial \theta^2} = (\bar{k}\bar{\gamma})^2\frac{\partial^2 \Omega^*}{\partial t^2} - m\mathrm{var}(k\gamma)\bar{\rho}_0\bar{\rho}_1 - m\phi,$$

using the fact that

$$\frac{\partial^2 \Gamma^*}{\partial \theta^2} = 0, \qquad \frac{\partial^2 \Pi^*}{\partial \theta^2} = (\bar{k}\bar{\gamma})^2\frac{\partial^2 \Pi^*}{\partial t^2},$$

and the fact that

$$\frac{\partial}{\partial \theta}\mathrm{E}_F\left[(1-\beta)\gamma\frac{\partial x^*}{\partial \theta} - k\gamma x^*\right] = 2\left[\mathrm{var}(k\gamma) + \frac{n}{1+n}(\bar{k}\bar{\gamma})^2\right]\bar{\rho}_0\bar{\rho}_1,$$

we finally obtain

$$\frac{\partial^2 V^{**}}{\partial \theta^2} = (\bar{k}\bar{\gamma})^2\frac{\partial^2 V^{**}}{\partial t^2} - m\left[(1-2\mu_1)\mathrm{var}(k\gamma) - 2\mu_1\frac{n}{1+n}(\bar{k}\bar{\gamma})^2\right]\bar{\rho}_0\bar{\rho}_1 - m\phi. \tag{A.12}$$

By differentiating Eq. (A.7) with respect to θ, we get

$$\frac{\partial^2 V^{**}}{\partial t\partial \theta} = \frac{\partial^2 \Omega^*}{\partial t\partial \theta} - m\mu_1\bar{k}\bar{\gamma}\frac{\partial X^*}{\partial t} + m\mu_1\frac{\partial^2 \Gamma^*}{\partial t\partial \theta} + m\mu_2\frac{\partial^2 \Pi^*}{\partial t\partial \theta}.$$

Since

$$\frac{\partial^2 \Omega^*}{\partial t \partial \theta} = \bar{k}\bar{\gamma}\frac{\partial^2 \Omega^*}{\partial t^2}, \qquad \frac{\partial^2 \Gamma^*}{\partial t \partial \theta} = 0, \qquad \frac{\partial^2 \Pi^*}{\partial t \partial \theta} = \bar{k}\bar{\gamma}\frac{\partial^2 \Pi^*}{\partial t^2},$$

we obtain

$$\frac{\partial^2 V^{**}}{\partial t \partial \theta} = \bar{k}\bar{\gamma}\frac{\partial^2 V^{**}}{\partial t^2} + m\frac{n}{1+n}\mu_1 \bar{k}\bar{\gamma}\bar{\rho}_0\bar{\rho}_1. \tag{A.13}$$

Using Eqs. (A.9), (A.12) and (A.13), we then characterize the condition for which

$$\frac{\partial^2 V^{**}}{\partial t^2}\frac{\partial^2 V^{**}}{\partial \theta^2} - \left(\frac{\partial^2 V^{**}}{\partial t \partial \theta}\right)^2 > 0, \tag{A.14}$$

which reduces to the second condition shown in Eq. (64). If conditions (A.14) and (A.9) hold true, then the derivative (A.12) is negative. Hence the function V^{**} is concave in (t, θ).

A.5 Proof of Proposition 7

Using Eq. (32), from Eq. (A.7) we get the first order condition for the equilibrium tax rate as:

$$\frac{1}{m}\frac{\partial V^{**}}{\partial t} = \left[(p^* - c) - (1-\mu_1)(1-\bar{\beta})\bar{\gamma}\right]\frac{\partial X^*}{\partial t} - (1-\mu_1)\frac{\partial \Gamma^*}{\partial t} + \mu_2\frac{\partial \Pi^*}{\partial t} = 0. \tag{A.15}$$

Using Eqs. (A.8), (14) and (33) to substitute the corresponding expressions into Eq. (A.15), and then solving for t, we obtain the equilibrium tax rate defined in Eq. (65). By simple differentiation, it is then immediate to see that $t^{**}(.)$ is decreasing in μ_1 and μ_2.

Using Eqs. (40), (39) and (A.11), from Eq. (A.10) we define the first order condition for the equilibrium level of θ (interior solution) as

$$\begin{aligned} -(1-\mu_1)\mathrm{E}_F\left[(1-\beta)\gamma\frac{\partial x^*}{\partial \theta}\right] - \mu_1\mathrm{E}_F\left[k\gamma x^*\right] + \mathrm{E}_F\left[(p^*-c)\frac{\partial x^*}{\partial \theta}\right] + \\ -(1-\mu_1)\bar{k}\bar{\gamma}\frac{\partial \Gamma^*}{\partial t} - \phi\theta + \mu_2\bar{k}\bar{\gamma}\frac{\partial \Pi^*}{\partial t} = 0. \end{aligned} \tag{A.16}$$

By taking the expectation, and using Eqs. (12), (15) and (39), Eq. (A.16) can be written as

$$-(1-\mu_1)\mathrm{cov}\left((1-\beta)\gamma, \frac{\partial x^*}{\partial \theta}\right) - \mu_1\mathrm{E}_F\left[k\gamma x^*\right] - \phi\theta + \bar{k}\bar{\gamma}\frac{1}{m}\frac{\partial V^{**}}{\partial t} = 0. \tag{A.17}$$

With t set at its equilibrium level, the last term in Eq. (A.17) is zero. By substituting Eq. (42) for the covariance term into Eq. (A.17), we finally obtain Eq. (66) that defines the equilibrium level $\theta^{**}(r)$ of prevention policies with $t = t^{**}(\theta, r)$.

Let $R(\theta)$ be the right hand side of Eq. (66). The conditions for a unique interior solution $\theta^{**}(r)$ are

$$R(0) = (1-\mu_1)(1-\bar{b})\bar{k}\,\mathrm{var}(\gamma) - \mu_1\mathrm{E}_F\left[k\gamma x^*(t^{**}(0,r),0,r)\right]/(\bar{\rho}_0\bar{\rho}_1) > 0 \tag{A.18}$$

and

$$\frac{\partial R}{\partial \theta} = -\frac{\mu_1}{\phi + (1-\mu_1)\mathrm{var}(k\gamma)\bar{\rho}_0\bar{\rho}_1}\frac{\partial}{\partial \theta}\mathrm{E}_F\left[k\gamma x^*(t^{**}(\theta,r),\theta,r)\right] < 1. \tag{A.19}$$

Condition (A.18) is always satisfied for $\mu_1 = 0$. For $\mu_1 > 0$, the solution for θ is interior if $R(0) > 0$, while it is a corner one at $\theta = 0$ if $R(0) \leq 0$. Condition (A.19) is equivalent to the second condition shown in Eq. (64), which guarantees concavity of the objective function V^{**} in (t, θ). To see this, consider that

$$\frac{\partial}{\partial \theta} \mathrm{E}_F \left[k\gamma x^*(t^{**}(\theta, r), \theta, r) \right] = -\left[\mathrm{var}(k\gamma) + \frac{n\mu_1}{n - 2\mu_2} (\bar{k}\bar{\gamma})^2 \right] \bar{\rho}_0 \bar{\rho}_1,$$

so that it is immediate to see the equivalence between the conditions given in Eq. (64) and that given in Eq. (A.19).

The impact of the lobby weights on θ^{**} is obtained by implicit differentiation of the following identity:

$$\theta^{**} \equiv \frac{(1-\mu_1)(1-\bar{b})\bar{k}\,\mathrm{var}(\gamma) - \mu_1 \mathrm{E}_F \left[k\gamma x^*(t^{**}(\theta^{**}, r), \theta^{**}, r) \right] / (\bar{\rho}_0 \bar{\rho}_1)}{\phi/(\bar{\rho}_0 \bar{\rho}_1) + (1-\mu_1)\mathrm{var}(k\gamma)}.$$

Taking into account the second order condition shown in Eq. (64), one obtains that

$$\mathrm{sign}\left\{ \frac{\partial \theta^{**}}{\partial \mu_1} \right\} = -\mathrm{sign}\left\{ \phi(1-\bar{b})\bar{k}\,\mathrm{var}(\gamma) + (1 + \mu_1 \mathrm{var}(k\gamma))\mathrm{E}_F \left[k\gamma x^* \right] + \mu_1 \mathrm{E}_F \left[k\gamma \frac{\partial x^*}{\partial t} \frac{\partial t^{**}}{\partial \mu_1} \right] \right\},$$

which is negative since $\partial x^*/\partial t < 0$ and $\partial t^{**}/\partial \mu_1 < 0$. Similarly, since

$$\mathrm{sign}\left\{ \frac{\partial \theta^{**}}{\partial \mu_2} \right\} = -\mathrm{sign}\left\{ \mu_1 \mathrm{E}_F \left[k\gamma \frac{\partial x^*}{\partial t} \frac{\partial t^{**}}{\partial \mu_2} \right] \right\},$$

one sees that θ^{**} is decreasing in μ_2, since $\partial t^{**}/\partial \mu_2 < 0$.

Consider finally the derivative of Eq. (62) with respect to r, i.e.

$$\frac{1}{m}\frac{\partial V^{**}}{\partial r} = \frac{1}{m}\frac{\partial \Omega^*}{\partial r} + \mu_1 \left[(1-\bar{\beta})\bar{\gamma}\frac{\partial X^*}{\partial r} + \frac{\partial \Gamma^*}{\partial r} \right] + \mu_2 \frac{\partial \Pi^*}{\partial r}. \tag{A.20}$$

Using Eq. (47), Eq. (A.20) can be written as

$$\frac{1}{m}\frac{\partial V^{**}}{\partial r} = -\alpha \mathrm{E}_F \left[v^{\mathrm{u}}(x^{*\mathrm{u}}) - v^{\mathrm{r}}(x^{*\mathrm{r}}) \right] + (1-\mu_1)\left[\frac{1+n}{n}\alpha\bar{\xi}\frac{\partial \Gamma^*}{\partial t} + 2\alpha\eta_0(1-r)X^{*\mathrm{u}} \right] + \alpha\bar{\xi}\frac{1}{m}\frac{\partial V^{**}}{\partial t}. \tag{A.21}$$

With t set at its equilibrium level $t^{**}(\theta, r)$, the last term is zero. Therefore, using Eqs. (48) and (49), the marginal costs and marginal benefits functions of policy r in the presence of lobbying are defined as

$$\mathrm{MC}(r; \mu_1) = (1-\mu_1)\bar{\xi}\bar{\rho}_0\bar{\rho}_1\eta_0\alpha^2(1-r)^2 + \alpha\bar{\rho}_0\left(\bar{\xi} - \frac{1}{2}\bar{\rho}_1(\mathrm{var}(\xi) + \bar{\xi}^2) \right), \tag{A.22}$$

$$\mathrm{MB}(r; \mu_1) = (1-\mu_1)2\alpha\eta_0(1-r)\left. X^{*\mathrm{u}} \right|_{t=t^*(\theta,r)}. \tag{A.23}$$

An interior solution for r is then defined by the following equation:

$$2\alpha\eta_0(1-r)\left. X^{*\mathrm{u}} \right|_{t=t^*(\theta,r)} = \bar{\xi}\bar{\rho}_0\bar{\rho}_1\eta_0\alpha^2(1-r)^2 + \frac{\alpha\bar{\rho}_0\left(\bar{\xi} - \frac{1}{2}\bar{\rho}_1(\mathrm{var}(\xi) + \bar{\xi}^2) \right)}{1-\mu_1}. \tag{A.24}$$

Since the functions $\mathrm{MC}(r; \mu_1)$ and $\mathrm{MB}(r; \mu_1)$ share the same properties, up to the scalar μ_1, of, respectively, the functions $\mathrm{MC}(r)$ and $\mathrm{MB}(r)$, characterized in Lemma 1, from Eq. (A.24) it is immediate to see that the interior solution $r^{**}(\mu_1)$ is decreasing in μ_1.

Table 1: U.S. States Cigarette tax rates, Tax revenue, Tobacco control programs, Total Alciati score, Smoke free air laws index

STATE	CTR (¢ p.p.) 2014	REV ($ p.c.) 2011	TCP ($ p.c.) 2011	ALC (index 0-39) 2006	SFAL (index 0-46) 2008	STATE	CTR (¢ p.p.) 2014	REV ($ p.c.) 2011	TCP ($ p.c.) 2011	ALC (index 0-39) 2006	SFAL (index 0-46) 2008
Alabama	42,5 (1)	29,01	1,52	15	14	Nebraska	64,0	33,87	2,52	10	16
Alaska	200,0	85,05	15,73	14	13	Nevada	80,0	36,27	3,23	15	43
Arizona	200,0	50,66	3,43	9	45	New Hampshire	178,0	165,30	1,15	20	19
Arkansas	115,0	68,18	4,78	16	38	New Jersey	270,0	88,83	0,34	20	46
California	87,0	22,42	2,41	25	31	New Mexico	166,0	44,80	4,17	22	38
Colorado	84,0	33,56	1,91	14	46	New York	435,0 (1)	79,32	3,61	26	39
Connecticut	340,0	109,32	0,60	22	28	North Carolina	45,0	27,08	2,21	11	3
Delaware	160,0	138,56	10,94	21	41	North Dakota	44,0	29,88	13,94	12	31
Florida	133,9 (2)	65,63	3,64	13	38	Ohio	125,0	70,68	0,76	12	41
Georgia	37,0	19,82	0,62	15	30	Oklahoma	103,0	63,10	6,41	25	32
Hawaii	320,0	98,67	7,81	13	44	Oregon	131,0	54,89	2,70	16	26
Idaho	57,0	25,59	2,00	26	35	Pennsylvania	160,0	90,02	1,82	15	38
Illinois	198,0 (1)	44,35	1,43	9	41	Rhode Island	350,0	125,96	3,78	18	41
Indiana	99,5	68,75	1,73	17	4	South	57,0	29,56	2,16	14	13
Iowa	136,0	66,63	3,73	18	46	South Dakota	153,0	66,28	6,00	13	34
Kansas	79,0	33,31	1,13	14	17	Tennessee	62,0 3)	44,60	0,42	27	16
Kentucky	60,0 (3)	61,75	1,05	19	2	Texas	141,0	52,86	0,76	29	5
Louisiana	36,0	28,14	2,38	17	42	Utah	170,0	37,12	3,15	16	39
Maine	200,0	102,25	8,98	24	34	Vermont	262,0	108,41	9,65	28	33
Maryland	200,0	68,47	1,11	7	41	Virginia	30,0 (1)	19,89	1,41	16	11
Massachusetts	351,0	85,51	1,68	9	41	Washington	302,5	63,56	3,07	28	42
Michigan	200,0	92,94	0,64	13	15	West Virginia	55,0	59,27	4,01	12	4
Minnesota	283,0 (4)	80,60	4,05	16	17	Wisconsin	252,0	106,60	1,66	17	14
Mississippi	68,0	45,99	4,70	18	8	Wyoming	60,0	42,03	12,14	25	n.a.
Missouri	17,0 (1)	15,46	1,05	16	20	Dist. of Columbia	250,0 (5)	58,85	6,51	12	42
Montana	170,0	76,54	9,75	22	38	**U.S. Median**	**136,0**	**61,75**	**2,52**	**16**	**34**

CTR: Excise tax rate in USD cents per pack of 20 cigarettes. Source: Federation of Tax Administrators, January 1, 2014. Available at http://www.taxadmin.org/fta/rate/cigarette.pdf
(1) Counties and cities may impose an additional tax on a pack of cigarettes in AL, 1¢ to 6¢; IL, 10¢ to 15¢; MO, 4¢ to 7¢; NYC $1.50; TN, 1¢; and VA, 2¢ to 15¢. **(2)** Florida's rate includes a surcharge of $1 per pack. **(3)** Dealers pay an additional enforcement and administrative fee of 0.1¢ per pack in KY and 0.05¢ in TN. **(4)** In addition, Minnesota imposes an in lieu cigarette sales tax determined annually by the Department. The current rate is 36.2¢ through December 31, 2013. **(5)** In addition, DC imposes an in lieu cigarette sales tax calculated every March 31. The current rate is 36¢.

REV: Annual gross tax revenue from cigarette sales in USD, per capita. Data are based on fiscal years ending June 30. Source: CDC-STATE System: Trend Report.

TCP: Total funds allocated for tobacco control programs, in USD, per capita, summed from state, federal, ALF, and RWJF funding sources. Source: CDC-STATE System: Trend Report.

ALC: Total Alciati score (min: 0, max: 39). Source: ImpactTeen. The index measures the extensiveness of state tobacco control youth access laws as, for instance, the level of restrictions for minimum age provision, the degree of provisions for photo identification requirements to buy tobacco products, the level of restrictions on selling tobacco products through a vending machine, the degree of graduated penalties to retailers for violation of youth access laws, and so on. Source: ImpacTEEN.

SFAL: Smoke Free Air Laws index (min: 0, max: 46). Source: ImpactTeen. The index is an aggregate measure of the level of SFA restrictions by state laws in 12 classified sites: government worksites, private worksites, child care centers, health care facilities, restaurants, recreational and cultural facilities, public transit, shopping malls, public and private schools, free standing bars. This aggregate measure is our own computation from the disaggregated data computed by ImpacTEEN.

REV and TCP data: http://apps.nccd.cdc.gov/statesystem/TrendReport/TrendReports.aspx; ALC and SFAL data: http://www.impacteen.org/tobaccodata.htm

Table 2: Political Contributions and Excise Tax Revenues in Three Sectors of the US Economy (thousands of $)

	Political Contributions (2)			Federal, State and Local Excise Tax Revenue (6)			Federal Excise Tax Revenue (7)		
year (1)	Tobacco (3)	Oil & Gas (4)	Alcoholic Beverage (5)	Tobacco	Oil & gas	Alcoholic Beverage	Tobacco (8)	Oil & Gas (9)	Alcoholic Beverage (10)
2004	7.472	15.598	17.378	20.066.022	62.192.773	11.972.790	7.440.242	27.249.201	6.987.084
2005	2.074	4.134	4.986	20.745.443	68.868.880	12.200.382	7.408.184	33.102.179	7.075.242
2006	94.855	126.628	30.055	22.356.489	72.092.535	12.536.145	7.350.661	35.113.131	7.182.329
2007	14.243	6.812	7.254	23.022.449	73.388.159	12.837.894	7.194.012	35.539.118	7.231.414
2008	5.996	55.546	17.770	23.434.774	73.402.161	13.169.406	6.851.714	34.441.243	7.420.959
2009	3.460	7.724	6.941	28.715.866	71.399.512	13.322.406	11.548.854	33.569.490	7.423.710
2010	11.059	66.688	43.875	33.181.062	71.651.833	13.502.184	15.913.566	33.714.319	7.474.915
2011	6.590	15.855	21.364	33.172.167	74.969.659	13.830.991	15.518.459	33.742.304	7.590.691
2012	58.317	80.476	36.776	na	na	na	15.005.872	33.659.652	7.852.331
2013	6.825	26.288	15.238	na	na	na	14.323.320	33.607.917	7.849.067
2014	7.401	95.965	33.852	na	na	na	na	na	na
2004-2011	145.750	298.985	149.624	204.694.272	567.965.512	103.372.198	79.225.692	266.470.985	58.386.344
(2)/(6)*100	0,071	0,053	0,145						

(1) Election year when focusing on political contributions

(2) Contributions to candidates and committees, at the Federal, State and Local level. Source: followthemoney.org (accessed December 18, 2014)

(3) Follow the Money's industry classification: Tobacco companies & tobacco product sales (general business) and Tobacco (agriculture)

(4) Follow the Money's industry classification: Oil & gas (energy & natural resources)

(5) Follow the Money's industry classification: Beer, wine & liquor (general business)

(6) Federal tax revenue (7) plus State and Local excise tax revenues. The data source for State and Local excise tax revenues is the State & Local Government Finance Data Query System. http://slfdqs.taxpolicycenter.org/pages.cfm. The Urban Institute-Brookings Institution Tax Policy Center. Data from U.S. Census Bureau, Annual Survey of State and Local Government Finances, Government Finances, Volume 4, and Census of Governments (1977-2011). Date of Access: (29-Jul-2013).

(7) Federal excise taxes reported to or collected by the Internal Revenue Service, Alcohol and Tobacco Tax and Trade Bureau, and Customs Service, by type of excise tax, fiscal years 1999-2013 (Historical Table 20, IRS, accessed December 18, 2014)

(8) Tax revenue from domestic tobacco products

(9) Tax revenue from manufacturer's excise taxes on gasoline and diesel fuel, except for trains and intercity buses

(10) Tax revenue on domestic distilled spirits, wine and beer

Table 3: Donations to selected U.S. States Ballot Measures on Tobacco related issues from 2002 to 2012

Measure	State	Year	Brief description (*)	Pro Committees		Con Committees		Status
				n. of cmtes	contributions (USD)	n. of cmtes	contributions (USD)	
PROPOSITION 29 (PRIMARY)	California	2012	Tax increase earmarked for cancer research	3	18,347,472	2	48,051,888	FAILED
PROPOSITION B	Missouri	2012	Tax increase earmarked for prevention programs	1	4,436,027	2	6,960,759	FAILED
PROPOSITION 302	Arizona	2010	Repeal of earmarking of tax revenue	1	35,600	3	1,131,940	FAILED
MEASURE 50	Oregon	2007	Tax increase earmarked for welfare programs	6	4,135,262	2	12,133,898	FAILED
AMENDMENT 3	Missouri	2006	Tax increase earmarked for prevention programs	1	6,998,752	3	6,209,057	FAILED
AMENDMENT 4	Florida	2006	Earmarking of tax revenue for prevention programs	1	5,153,604	0	0	PASSED
MEASURE 2	South Dakota	2006	Tax increase earmarked for prevention programs	1	423,380	6	230,034	PASSED
PROPOSITION 203	Arizona	2006	Tax increase earmarked for welfare programs	2	3,469,464	1	9,451	PASSED
PROPOSITION 86	California	2006	Tax increase earmarked for welfare programs	2	16,607,128	5	66,682,899	FAILED
AMENDMENT 35	Colorado	2004	Tax increase earmarked for welfare programs	1	2,079,750	1	237,394	PASSED
I-149	Montana	2004	Tax increase and change in earmarking	1	249,800	1	98,997	PASSED
STATE QUESTION 713	Oklahoma	2004	New tax in place of the old one	1	1,199,068	1	2,074,664	PASSED
PROPOSITION 303	Arizona	2002	Tax increase	2	1,487,688	0	0	PASSED
INITIATED STATUTORY MEASURE 4	North Dakota	2012	Introduction of smoking bans	1	84,120	0	0	PASSED
REFERRED LAW 12	South Dakota	2010	Expansion of State smoking ban	4	418,830	1	197,175	PASSED
ISSUE 5 (**)	Ohio	2006	Introduction of smoking ban in public places	1	2,686,758	2	6,742,639	PASSED
PROPOSITION 201 (**)	Arizona	2006	Tax increase earmarked for prevention programs; Introduction of smoking ban in public places	1	1,810,401	2	8,805,169	PASSED
QUESTION 5 (**)	Nevada	2006	Introduction of smoking ban in public places	1	617,038	2	2,354,350	PASSED
INITIATIVE 901	Washington	2005	Expansion of State smoking ban	1	1,594,441	1	33,171	PASSED

Source: National Institute on Money in State Politics (http://www.followthemoney.org/)

data avaliable following the links *Explore - Ballot measures by subject* (accessed February 22,2014)

(*) A detailed description is given in Table 3bis

(**) Multiple ballot measures (see Table 3bis). The contributions shown in the table are referred to the multiple ballot.

Table 3bis: Detailed description of the Ballot Measures reported in Table 3

Measure	Description
PROPOSITION 29 (PRIMARY)	Imposes additional five cent tax on each cigarette distributed ($1.00 per pack), and an equivalent tax increase on other tobacco products, to fund cancer research and other specified purposes.
PROPOSITION B	Would create the Health and Education Trust Fund with proceeds of a tax of $0.0365 per cigarette and 25 percent of the manufacturer's invoice price for roll-your-own tobacco and 15 percent for other tobacco products
PROPOSITION 302	This measure would repeal the Arizona Early Childhood Development and Health Initiative, redirecting tobacco tax revenues into the state's general fund.
MEASURE 50	Increase tobacco tax and use funds to provide healthcare for children. Prevent tobacco use.
AMENDMENT 3	Amendment 3 would impose an 80 cent-per-pack tax on cigarettes to fund programs to reduce and prevent tobacco use.
AMENDMENT 4	Amendment 4 would require the state to use some tobacco settlement money annually for a statewide tobacco education and prevention program.
MEASURE 2	Measure 2 would increase the tax on cigarettes and tobacco products. The proposed law would deposit up to $30 million of tobacco tax revenue into the state general fund, the next $5 million, if any, would be deposited into the tobacco prevention and reduction trust fund.
PROPOSITION 203	Proposition 203 would establish an Early Childhood Development and Health Fund, consisting of revenues generated by an increase in the state tax on tobacco products, donations and state appropriations. The state tax on cigarettes would increase from $1.18 per pack to $1.98 per pack, and the tax on other types of tobacco products would be increased by a similar amount.
PROPOSITION 86	Proposition 86 would impose an additional 13 cent tax on each cigarette distributed ($2.60 per pack), and indirectly increases tax on other tobacco products. The funds generated from this increased tax would go towards health care and health insurance programs.
AMENDMENT 35	Amendment 35 would raise taxes on tobacco products and require that the new revenue be used for health care services and tobacco education programs.
I-149	I-149 would increase tobacco taxes by almost 140 percent and change the use of these tax revenues.
STATE QUESTION 713	Question 713 would end the sales taxes on cigarettes and tobacco products and replace it with a new tax. It also would make several income tax changes.
PROPOSITION 303	Proposition 303 would increase the state tax on cigarettes, cigars and other tobacco products.
INITIATED STATUTORY MEASURE 4	This measure would prohibit smoking, including the use of electronic smoking devices, in public places and worksites
REFERRED LAW 12	This measure would expand the state smoking ban to include all restaurants, bars, liquor stores, Deadwood casinos, and video lottery establishments. The ban does not extend to existing cigar bars, tobacco shops, or designated smoking rooms in hotels.
ISSUE 5 (multiple ballot measure)	Issue 5 would ban smoking in public places (SmokeFree Ohio). Issue 4 is an alternative to Issue 5, and would ban smoking in public places but exempts bars, restaurants, and other locations. Issue 5 passed while Issue 4 failed. Committees supported/opposed multiple ballot measures.
PROPOSITION 201 (multiple ballot measure)	Proposition 201 would prohibit smoking in all public places and places of employment, except in tobacco shops, outdoor patios, veterans and fraternal clubs when they are not open to the public, and hotel rooms designated as smoking rooms. The measure would also increase the state tax on cigarettes from $1.18 per pack to $1.20 per pack. Revenues collected from this tax would pay for enforcement and education costs. Proposition 206 is an alternative to Proposition 201, and would prohibit smoking in enclosed public places and places of employment, except bars and certain areas of restaurants, tobacco shops, outdoor patios, veterans and fraternal clubs when they are not open to the public, and hotel rooms designated as smoking rooms. Proposition 201 passed while Proposition 206 failed. Committees supported/opposed multiple ballot measures.
QUESTION 5 (multiple ballot measure)	Question 5 would prohibit smoking in certain public places, in all bars with a food-handling license, but would exclude gaming areas of casinos and certain other locations. The measure would also allow local governments to adopt tobacco control measures stricter than those in question 5. Question 4 would prohibit smoking in certain public places, except all areas of casinos, gaming areas within establishments holding gaming licenses, bars and certain other locations. The measure would also provide that only the Nevada legislature may regulate the smoking of tobacco. Question 5 passed while Question 4 failed. Committees supported/opposed multiple ballot measures.
INITIATIVE 901	Initiative 901 would prohibit smoking in public places and in places of employment, including restaurants, bars, taverns, bowling alleys and tobacco shops.

2011

2011/1, Oppedisano, V; Turati, G.: "What are the causes of educational inequalities and of their evolution over time in Europe? Evidence from PISA"
2011/2, Dahlberg, M; Edmark, K; Lundqvist, H.: "Ethnic diversity and preferences for redistribution"
2011/3, Canova, L.; Vaglio, A.: "Why do educated mothers matter? A model of parental help"
2011/4, Delgado, F.J.; Lago-Peñas, S.; Mayor, M.: "On the determinants of local tax rates: new evidence from Spain"
2011/5, Piolatto, A.; Schuett, F.: "A model of music piracy with popularity-dependent copying costs"
2011/6, Duch, N.; García-Estévez, J.; Parellada, M.: "Universities and regional economic growth in Spanish regions"
2011/7, Duch, N.; García-Estévez, J.: "Do universities affect firms' location decisions? Evidence from Spain"
2011/8, Dahlberg, M.; Mörk, E.: "Is there an election cycle in public employment? Separating time effects from election year effects"
2011/9, Costas-Pérez, E.; Solé-Ollé, A.; Sorribas-Navarro, P.: "Corruption scandals, press reporting, and accountability. Evidence from Spanish mayors"
2011/10, Choi, A.; Calero, J.; Escardíbul, J.O.: "Hell to touch the sky? Private tutoring and academic achievement in Korea"
2011/11, Mira Godinho, M.; Cartaxo, R.: "University patenting, licensing and technology transfer: how organizational context and available resources determine performance"
2011/12, Duch-Brown, N.; García-Quevedo, J.; Montolio, D.: "The link between public support and private R&D effort: What is the optimal subsidy?"
2011/13, Breuillé, M.L.; Duran-Vigneron, P.; Samson, A.L.: "To assemble to resemble? A study of tax disparities among French municipalities"
2011/14, McCann, P.; Ortega-Argilés, R.: "Smart specialisation, regional growth and applications to EU cohesion policy"
2011/15, Montolio, D.; Trillas, F.: "Regulatory federalism and industrial policy in broadband telecommunications"
2011/16, Pelegrín, A.; Bolancé, C.: "Offshoring and company characteristics: some evidence from the analysis of Spanish firm data"
2011/17, Lin, C.: "Give me your wired and your highly skilled: measuring the impact of immigration policy on employers and shareholders"
2011/18, Bianchini, L.; Revelli, F.: "Green polities: urban environmental performance and government popularity"
2011/19, López Real, J.: "Family reunification or point-based immigration system? The case of the U.S. and Mexico"
2011/20, Bogliacino, F.; Piva, M.; Vivarelli, M.: "The impact of R&D on employment in Europe: a firm-level analysis"
2011/21, Tonello, M.: "Mechanisms of peer interactions between native and non-native students: rejection or integration?"
2011/22, García-Quevedo, J.; Mas-Verdú, F.; Montolio, D.: "What type of innovative firms acquire knowledge intensive services and from which suppliers?"
2011/23, Banal-Estañol, A.; Macho-Stadler, I.; Pérez-Castrillo, D.: "Research output from university-industry collaborative projects"
2011/24, Ligthart, J.E.; Van Oudheusden, P.: "In government we trust: the role of fiscal decentralization"
2011/25, Mongrain, S.; Wilson, J.D.: "Tax competition with heterogeneous capital mobility"
2011/26, Caruso, R.; Costa, J.; Ricciuti, R.: "The probability of military rule in Africa, 1970-2007"
2011/27, Solé-Ollé, A.; Viladecans-Marsal, E.: "Local spending and the housing boom"
2011/28, Simón, H.; Ramos, R.; Sanromá, E.: "Occupational mobility of immigrants in a low skilled economy. The Spanish case"
2011/29, Piolatto, A.; Trotin, G.: "Optimal tax enforcement under prospect theory"
2011/30, Montolio, D; Piolatto, A.: "Financing public education when altruistic agents have retirement concerns"
2011/31, García-Quevedo, J.; Pellegrino, G.; Vivarelli, M.: "The determinants of YICs' R&D activity"
2011/32, Goodspeed, T.J.: "Corruption, accountability, and decentralization: theory and evidence from Mexico"
2011/33, Pedraja, F.; Cordero, J.M.: "Analysis of alternative proposals to reform the Spanish intergovernmental transfer system for municipalities"
2011/34, Jofre-Monseny, J.; Sorribas-Navarro, P.; Vázquez-Grenno, J.: "Welfare spending and ethnic heterogeneity: evidence from a massive immigration wave"
2011/35, Lyytikäinen, T.: "Tax competition among local governments: evidence from a property tax reform in Finland"
2011/36, Brülhart, M.; Schmidheiny, K.: "Estimating the Rivalness of State-Level Inward FDI"
2011/37, García-Pérez, J.I.; Hidalgo-Hidalgo, M.; Robles-Zurita, J.A.: "Does grade retention affect achievement? Some evidence from Pisa"
2011/38, Boffa, f.; Panzar. J.: "Bottleneck co-ownership as a regulatory alternative"

2011/39, González-Val, R.; Olmo, J.: "Growth in a cross-section of cities: location, increasing returns or random growth?"
2011/40, Anesi, V.; De Donder, P.: "Voting under the threat of secession: accommodation vs. repression"
2011/41, Di Pietro, G.; Mora, T.: "The effect of the l'Aquila earthquake on labour market outcomes"
2011/42, Brueckner, J.K.; Neumark, D.: "Beaches, sunshine, and public-sector pay: theory and evidence on amenities and rent extraction by government workers"
2011/43, Cortés, D.: "Decentralization of government and contracting with the private sector"
2011/44, Turati, G.; Montolio, D.; Piacenza, M.: "Fiscal decentralisation, private school funding, and students' achievements. A tale from two Roman catholic countries"

2012

2012/1, Montolio, D.; Trujillo, E.: "What drives investment in telecommunications? The role of regulation, firms' internationalization and market knowledge"
2012/2, Giesen, K.; Suedekum, J.: "The size distribution across all "cities": a unifying approach"
2012/3, Foremny, D.; Riedel, N.: "Business taxes and the electoral cycle"
2012/4, García-Estévez, J.; Duch-Brown, N.: "Student graduation: to what extent does university expenditure matter?"
2012/5, Durán-Cabré, J.M.; Esteller-Moré, A.; Salvadori, L.: "Empirical evidence on horizontal competition in tax enforcement"
2012/6, Pickering, A.C.; Rockey, J.: "Ideology and the growth of US state government"
2012/7, Vergolini, L.; Zanini, N.: "How does aid matter? The effect of financial aid on university enrolment decisions"
2012/8, Backus, P.: "Gibrat's law and legacy for non-profit organisations: a non-parametric analysis"
2012/9, Jofre-Monseny, J.; Marín-López, R.; Viladecans-Marsal, E.: "What underlies localization and urbanization economies? Evidence from the location of new firms"
2012/10, Mantovani, A.; Vandekerckhove, J.: "The strategic interplay between bundling and merging in complementary markets"
2012/11, Garcia-López, M.A.: "Urban spatial structure, suburbanization and transportation in Barcelona"
2012/12, Revelli, F.: "Business taxation and economic performance in hierarchical government structures"
2012/13, Arqué-Castells, P.; Mohnen, P.: "Sunk costs, extensive R&D subsidies and permanent inducement effects"
2012/14, Boffa, F.; Piolatto, A.; Ponzetto, G.: "Centralization and accountability: theory and evidence from the Clean Air Act"
2012/15, Cheshire, P.C.; Hilber, C.A.L.; Kaplanis, I.: "Land use regulation and productivity – land matters: evidence from a UK supermarket chain"
2012/16, Choi, A.; Calero, J.: "The contribution of the disabled to the attainment of the Europe 2020 strategy headline targets"
2012/17, Silva, J.I.; Vázquez-Grenno, J.: "The ins and outs of unemployment in a two-tier labor market"
2012/18, González-Val, R.; Lanaspa, L.; Sanz, F.: "New evidence on Gibrat's law for cities"
2012/19, Vázquez-Grenno, J.: "Job search methods in times of crisis: native and immigrant strategies in Spain"
2012/20, Lessmann, C.: "Regional inequality and decentralization – an empirical analysis"
2012/21, Nuevo-Chiquero, A.: "Trends in shotgun marriages: the pill, the will or the cost?"
2012/22, Piil Damm, A.: "Neighborhood quality and labor market outcomes: evidence from quasi-random neighborhood assignment of immigrants"
2012/23, Ploeckl, F.: "Space, settlements, towns: the influence of geography and market access on settlement distribution and urbanization"
2012/24, Algan, Y.; Hémet, C.; Laitin, D.: "Diversity and local public goods: a natural experiment with exogenous residential allocation"
2012/25, Martinez, D.; Sjögren, T.: "Vertical externalities with lump-sum taxes: how much difference does unemployment make?"
2012/26, Cubel, M.; Sanchez-Pages, S.: "The effect of within-group inequality in a conflict against a unitary threat"
2012/27, Andini, M.; De Blasio, G.; Duranton, G.; Strange, W.C.: "Marshallian labor market pooling: evidence from Italy"
2012/28, Solé-Ollé, A.; Viladecans-Marsal, E.: "Do political parties matter for local land use policies?"
2012/29, Buonanno, P.; Durante, R.; Prarolo, G.; Vanin, P.: "Poor institutions, rich mines: resource curse and the origins of the Sicilian mafia"
2012/30, Anghel, B.; Cabrales, A.; Carro, J.M.: "Evaluating a bilingual education program in Spain: the impact beyond foreign language learning"
2012/31, Curto-Grau, M.; Solé-Ollé, A.; Sorribas-Navarro, P.: "Partisan targeting of inter-governmental transfers & state interference in local elections: evidence from Spain"

2012/32, Kappeler, A.; Solé-Ollé, A.; Stephan, A.; Välilä, T.: "Does fiscal decentralization foster regional investment in productive infrastructure?"
2012/33, Rizzo, L.; Zanardi, A.: "Single vs double ballot and party coalitions: the impact on fiscal policy. Evidence from Italy"
2012/34, Ramachandran, R.: "Language use in education and primary schooling attainment: evidence from a natural experiment in Ethiopia"
2012/35, Rothstein, J.: "Teacher quality policy when supply matters"
2012/36, Ahlfeldt, G.M.: "The hidden dimensions of urbanity"
2012/37, Mora, T.; Gil, J.; Sicras-Mainar, A.: "The influence of BMI, obesity and overweight on medical costs: a panel data approach"
2012/38, Pelegrín, A.; García-Quevedo, J.: "Which firms are involved in foreign vertical integration?"
2012/39, Agasisti, T.; Longobardi, S.: "Inequality in education: can Italian disadvantaged students close the gap? A focus on resilience in the Italian school system"

2013

2013/1, Sánchez-Vidal, M.; González-Val, R.; Viladecans-Marsal, E.: "Sequential city growth in the US: does age matter?"
2013/2, Hortas Rico, M.: "Sprawl, blight and the role of urban containment policies. Evidence from US cities"
2013/3, Lampón, J.F.; Cabanelas-Lorenzo, P-; Lago-Peñas, S.: "Why firms relocate their production overseas? The answer lies inside: corporate, logistic and technological determinants"
2013/4, Montolio, D.; Planells, S.: "Does tourism boost criminal activity? Evidence from a top touristic country"
2013/5, Garcia-López, M.A.; Holl, A.; Viladecans-Marsal, E.: "Suburbanization and highways: when the Romans, the Bourbons and the first cars still shape Spanish cities"
2013/6, Bosch, N.; Espasa, M.; Montolio, D.: "Should large Spanish municipalities be financially compensated? Costs and benefits of being a capital/central municipality"
2013/7, Escardíbul, J.O.; Mora, T.: "Teacher gender and student performance in mathematics. Evidence from Catalonia"
2013/8, Arqué-Castells, P.; Viladecans-Marsal, E.: "Banking towards development: evidence from the Spanish banking expansion plan"
2013/9, Asensio, J.; Gómez-Lobo, A.; Matas, A.: "How effective are policies to reduce gasoline consumption? Evaluating a quasi-natural experiment in Spain"
2013/10, Jofre-Monseny, J.: "The effects of unemployment benefits on migration in lagging regions"
2013/11, Segarra, A.; García-Quevedo, J.; Teruel, M.: "Financial constraints and the failure of innovation projects"
2013/12, Jerrim, J.; Choi, A.: "The mathematics skills of school children: How does England compare to the high performing East Asian jurisdictions?"
2013/13, González-Val, R.; Tirado-Fabregat, D.A.; Viladecans-Marsal, E.: "Market potential and city growth: Spain 1860-1960"
2013/14, Lundqvist, H.: "Is it worth it? On the returns to holding political office"
2013/15, Ahlfeldt, G.M.; Maennig, W.: "Homevoters vs. leasevoters: a spatial analysis of airport effects"
2013/16, Lampón, J.F.; Lago-Peñas, S.: "Factors behind international relocation and changes in production geography in the European automobile components industry"
2013/17, Guío, J.M.; Choi, A.: "Evolution of the school failure risk during the 2000 decade in Spain: analysis of Pisa results with a two-level logistic mode"
2013/18, Dahlby, B.; Rodden, J.: "A political economy model of the vertical fiscal gap and vertical fiscal imbalances in a federation"
2013/19, Acacia, F.; Cubel, M.: "Strategic voting and happiness"
2013/20, Hellerstein, J.K.; Kutzbach, M.J.; Neumark, D.: "Do labor market networks have an important spatial dimension?"
2013/21, Pellegrino, G.; Savona, M.: "Is money all? Financing versus knowledge and demand constraints to innovation"
2013/22, Lin, J.: "Regional resilience"
2013/23, Costa-Campi, M.T.; Duch-Brown, N.; García-Quevedo, J.: "R&D drivers and obstacles to innovation in the energy industry"
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