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Smoking bans and the secondhand smoking problem: an economic analysis

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Abstract Smoking bans are gaining widespread support in the European Union and other countries. The vast majority of these bans are partial bans given that smoking is still permitted in certain places. This article investigates the role of partial smoking bans in coping with externalities caused by the secondhand smoking problem. Although it is widely known that Pigouvian taxation is superior to a perfect ban, this result does not necessarily carry over to a *partial* ban because taxes cannot (easily) be differentiated according to location. We show that under an easy and intuitive condition, (1) enacting a partial smoking ban alone always improves social welfare (a) in an unregulated society and (b) even in a regulated society if externalities can be eliminated, and (2) it is ensured that a combination of Pigouvian tax and a partial smoking ban leads to a higher social optimum than implementing corrective Pigouvian taxation alone.

Keywords Smoking bans · Externalities · Public health policy

JEL Classification C72 · H30 · I18

Introduction

Smoking constitutes one of the greatest public health problems of the last—and probably of the current—century. Tobacco consumption substantially reduces life expectancy and is the leading cause of cancer as well as a major risk factor for heart attack, stroke, and pulmonary disease. Reduction of the social cost of smoking is one of the main reasons for public intervention. Regulations that restrict smoking in public places, especially bars and restaurants, have sparked heated debates across many countries. Internationally, bans exist all over the world. Since smoking bans can have a substantial impact on public health, it is crucial to study appropriate policies. This paper deals with the impact of secondhand smoke in a society. Hence, we focus on the indirect effects of smoking. Secondhand smoke, also known as environmental tobacco smoke, has substantial effects on health. We study whether enacting a smoking ban may increase welfare.[1]

Smoking bans are gaining widespread support. Most European and many other countries have recently enacted partial smoking bans. This trend has become apparent in all over the world. An overview for Europe is given in Table 1. Since smoking bans have become a widespread phenomenon, this type of regulation needs to be evaluated in detail and discussed from an economic viewpoint. We attempt to provide insight into the economic implications

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[1] Of course, the direct health effects of smoking are enormous. We do, however, focus on the indirect effects in order to analyze the impact of public policy on the secondhand smoking problem. There is an extensive literature on direct impacts of smoking on health and welfare. First important research has been conducted around 1950–1960 by Wynder and Graham [45], Doll and Hill [9], Hammond and Horn [18] as well as Hammond and Horn [19] who were followed by countless others. The value of loss in life due to smoking is significant as shown by Viscusi [41] and Viscusi and Aldy [42]. In a more recent study, Viscusi and Hersch [43] use a general formulation of the present value of the mortality cost of smoking. Strikingly, they find that the expected discounted mortality cost per pack in 2006 Dollars using a 3% discount rate is about $222 for male and $94 for female smokers. This is considerably above previous estimates.

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Table 1 Introduction of smoking bans in Europe

Country	Year
Italy, Ireland, Malta, Norway	2004
Bulgaria	2005
Albania, Spain	2006
Austria, Belgium, Czech Republic, Estonia, Finland	2007
France, Iceland, United Kingdom, Lithuania, Germany, Greece	2009

of recently enacted smoking bans in the European Union and other countries. Taking into account that individuals in a society are heterogenous and may make different choices when it comes to smoking habits, we investigate circumstances under which such partial smoking bans may be an economically efficient policy in this central area of public health.

Smoking bans are a relatively young phenomenon.[2] As the number of countries introducing smoking bans has grown, so too has the number of studies that have investigated the impact of these bans on tobacco consumption and public health. There is a vast empirical literature that cannot be reviewed here. For the United States, for example, the Centers for Disease Control and Prevention (CDC) asked the Institute of Medicine to convene a committee to assess the association between secondhand smoke exposure and cardiovascular disease or heart attacks. Data consistently indicate that secondhand smoke exposure increases the risk of coronary heart disease by 25–30%. Remarkably, it also highlights the impact of a smoking ban of the rate of heart attacks: Most studies find a decrease in the rate of heart attacks after implementation of a smoking ban. Decreases ranged from 6 to 47%, depending on the form of analysis.[3] These findings are confirmed by Lightwood and Glantz [24] and Meyers et al. [28]. Nevertheless, adverse health effects of secondhand smoke on nonsmokers' health seem, however, complex. For instance, there is no scientific evidence that short-term, transient exposure to secondhand smoke significantly increases the risk of cardiovascular disease in otherwise healthy nonsmokers. In particular, the possibility that such transient exposure could increase the risk of acute myocardial infarction seems speculative [34, 38]. Also, the association between secondhand smoke exposure and coronary heart disease and lung cancer may be considerably weaker than generally believed [11].

Although most of the empirical literature confirms the reducing effect of smoking bans on cigarette consumption, to the best of our knowledge, there is no *theoretical* study that explicitly examines the implications of smoking bans on social welfare in a microeconomic framework. The present paper attempts to fill this gap.

The main reason for introducing smoking bans in many countries all over the world seems to be their potential of substantially reducing well-known secondhand smoking-related diseases as well as the considerable treatment costs associated with these diseases.[4] From an economist's viewpoint, there is an *externality problem*: Smokers create secondhand-smoke that harms other individuals around them; in particular, secondhand-smoke increases the risk of developing smoking-related diseases like coronary heart disease and acute myocardial infarction in nonsmokers. This is well known as the secondhand smoking problem.[5] Generally, as it is known in public economics, externalities imply market failure. Referring to the secondhand smoking problem, a market exhibiting risk externalities leads to a socially inefficient outcome: The secondhand smoking-related risk of disease is "too high" from a social planner's viewpoint. This market failure is commonly corrected via a Pigouvian tax.[6]

It is often argued that—theoretically—the externality problem would be solved by the market if one allows for validity of the *Coase Theorem*. Coase [7] argued that, under certain conditions, private markets internalize negative externalities: Provided that economic agents have the possibility to carry out free negotiations and to conclude binding contracts, given a world with perfect information, without transaction costs and without wealth effects on demand, the allocation of resources is optimal and invariant with respect to the assignment of property rights. Under such circumstances, parties damaged by externalities pay the liable parties a compensation for reducing externalities.[7] It is well known, however, that the Coasean assumptions—especially the zero transaction costs assumption—severely restrict the theorem's domain of validity. A Coasean solution also requires that parties are willing to ask or accept side payments. This seems difficult in social interaction among friends or colleagues. Although researchers tackle with the implications of the Coase Theorem on smoking, the necessary assumptions about property rights in this context seem controversial. The Coase Theorem's applicability is discussed by Henderson [20] as well as Alamar and Glantz [5]. Phelps [32], for instance, notes that "trying to use agreements…between people in a restaurant to determine whether smoking would take place would be the height of

[2] In 1990 the first restaurant and bar smoking ban was passed by San Luis Obispo in California. See Phelps [33].

[3] See Institute of Medicine [22].

[4] The American Heart Association, for instance, estimates that between 35,000 and 40,000 heart disease death occur every year only due to environmental tobacco smoke. See Taylor et al. [40].

[5] See Lee [23, p. 156].

[6] See Pigou [35].

[7] See Gifford and Stone [14] for a technical proof.

absurdity, and nobody would think seriously of a full 'property rights' approach to such a problem. The transaction costs of reaching agreements would overwhelm the problem."[8]

Another situation is smoking externalities within a family or the same household. Here, it seems more realistic to assume that a Coasean solution can be found by an agreement between family members. Indeed, empirically, a large part of secondhand smoke comes from exposure at home where smokers contaminate nonsmokers living in the same household. Public smoking bans might have a perverse effect by displacing smokers from public places to private ones [2]. If a person lives alone, this shifting of smoking habits may reduce externalities. However, multiple empirical studies suggest that people tend to reduce smoking at home (or quit entirely) when there are workplace smoking restrictions [12, 13, 16, 25]. If a person lives with others in the same household, it seems not far from reasonable to assume that the Coase Theorem may be applicable and the household members will agree on a satisfying outcome for all of them. In contrast to these special locations, our focus is on anonymous and stochastic externalities from smoking, i.e., externalities occurring from a somewhat random gathering of people in public places.

Basically, there are two main motives for introducing a tax on cigarettes: Firstly, tobacco consumption is reduced. This effect is desired given that smoking is harmful to the health of smokers (and others). Tobacco is a demerit good as introduced by Musgrave [29] and Musgrave [30]. Following Musgrave, tobacco is a good whose consumption is considered unhealthy due to the perceived negative effects on health. Due to this feature, governments often levy taxes on tobacco. Secondly, a tax can correct negative externalities. There is an important difference between demerit goods and negative externalities. Negative externalities occur when the consumption of the good has measurable negative consequences for others who do not (directly) consume the good themselves (here secondhand smoking). This interpretation is supported by the smoking policy in many countries. Since the focus of this paper is on the secondhand smoking problem, we do not further refer to the demerit good character of tobacco. We interpret tobacco taxes at least partly as Pigouvian taxes.[9] Tobacco taxes seem indeed very high compared to taxes on other unhealthy products. Therefore, an important part of the tax can be viewed as externality-driven.[10]

We follow the standard economic model by assuming that individuals manage both their health-related habits and risk of disease in a rational manner, adapting one or the other when the benefits from doing so outweigh the costs. As a result, we examine smoking behavior from a rational-choice perspective.[11] It is one of our main contributions in this article to examine the impact of individual smoking utilities or preferences on cigarette demand and its effect on the extent of secondhand smoke in society. Taking into account that smoking bans are associated with individual cost for smokers, i.e., forcing smokers to smoke outdoors raises the time and discomfort associated with smoking, we aim to study whether regulation in the actual form of partial smoking bans is the most favorable public health policy to bring about social benefits. In a simple model with heterogeneous consumers, we compare the well-known Pigouvian taxation approach (which is the common measure to internalize externalities and increase social welfare) with smoking bans. A ban on smoking may be perfect or partial. It may be combined with Pigouvian taxation or not. But which is the best option? To answer this question, we analyze and compare these alternatives of public policy makers in a simple expected-utility framework. To the best of our knowledge, this study is the first to explicitly study partial smoking bans in such a framework.

The remainder of the paper is structured as follows. In the next section, we introduce a simple model of multiple individuals with different preferences for smoking. We first demonstrate that the unregulated situation is inefficient due to the presence of externalities in the form of secondhand smoking. The following section studies—within our model framework—the effects of introducing a perfect or a partial smoking ban and/or Pigouvian taxation in order to internalize smoking externalities. We then evaluate all alternatives with respect to social welfare. We show that the potential benefit of enacting a partial smoking ban decisively depends on the relationship between the smokers' disutility from the ban and the reduction in externalities such a ban may produce. Finally, we discuss under which circumstances markets can solve the externality problem. Concluding remarks and a short discussion of main implications of our analysis for public policy makers follow.

8 See Phelps [32, p. 430]. Taking into account the unequal power in the relationship between employees and employers reinforces the problem. We discuss a possible market solution in Sect. 2.5 below.

9 Empirical analyses suggest that people are responsive to cigarette price changes, i.e. the elasticity of demand is nonzero. See, for instance, Wasserman et al. [44, p. 62].

10 To correct for drinking externalities, laws that prohibit drunken driving might similarly be interpreted as partial drinking bans.

11 See Grossman [17] or Hirshleifer and Riley [21] for early studies on rational-choice models. Although rational addiction is the dominant economic model, it is not the only one. See, for instance, Alamar and Glantz [4].

The model

Assumptions

We assume that individuals are rational and act in their own best interest, i.e., their decision to smoke or not is a function of their individual value attributed to smoking and their related health risk perception. Hence, smoking and nonsmoking decisions are undertaken in order to maximize expected utility. Given different preferences in society, some individuals choose to smoke even though tobacco consumption may have a negative impact on their health.[12]

Assume a society consisting of a continuum of individuals with (a priori) health status h. If there are smokers in the society, nonsmokers will be exposed to some risk of disease due to secondhand smoke exposure. In case of manifestation of disease, their health status is reduced to $h - s$, assuming $h > s$, so that s might be interpreted as the "smoking-induced damage" to health. Individuals attribute individually different utility $u \in [0, \overline{u}]$ to smoking. Without loss of generality, we normalize the number of individuals in society to unity. Each individual decides whether she likes to be a smoker or a nonsmoker. Due to individually different utilities attributed to smoking, being a nonsmoker may be more painful for some individuals than for others. Basically, there are two underlying sources of smoking-related disease: Either the disease is directly caused by an individual herself through active smoking, or the disease is the consequence of exposure to secondhand smoke from others (secondhand smoking). We assume that an individual can only influence the first risk source. This *direct* risk source can be prevented by not smoking while the *indirect* source of risk cannot be influenced. Even if an individual does not smoke, she is exposed to some indirect risk of disease due to the smokers' behavior. The probability that a disease is caused directly due to (active) smoking is $p \in (0, 1)$. The probability that an individual becomes sick due to secondhand smoking is $\tilde{q}(x)$, where $x \in [0, 1]$ indicates the share of smokers in the population. Of course, the higher the share of smokers x, the higher is the indirect risk of secondhand smoking-related disease, i.e., $\tilde{q}'(x) > 0$. To simplify the analysis, we assume that the secondhand-smoke exposure is measured by $\tilde{q}(x) \equiv qx$.[13] Our assumptions can be interpreted as follows: If everybody smokes ($x = 1$), then q is the maximum indirect risk; if nobody smokes ($x = 0$), then, of course, the indirect risk is zero. We also assume that smoking is always worthwhile for some individuals, i.e., expected "damage" to those individuals' health is smaller than smoking utility (even if everybody else smokes): $\overline{u} > ps > 0$.

Individuals with low utility u will tend to be nonsmokers while individuals with high utility will tend to be smokers. We make the very general assumption that overall smoking utilities are given by a (nondegenerate) distribution function $F(u)$ with continuous density $f(u)$ defined over $[0, \overline{u}]$. A smoker's expected utility is[14]

$$S(x, u) = h + u - (p + (1 - p)qx)s, \tag{1}$$

while a nonsmoker's expected utility is

$$N(x) = h - qxs. \tag{2}$$

An individual will be a nonsmoker if her excess of expected utility is nonnegative, i.e., if

$$\Delta(x, u) = N(x) - S(x, u) \geq 0. \tag{3}$$

Unregulated society

In the following, we study what we call an unregulated society. An unregulated society is a society where no legal smoking restrictions exist, i.e., a society absent regulation.

An individual with utility u will be indifferent between smoking and not smoking if $\Delta(x, u) = 0$. Assume the indifferent individual has utility $\widehat{u}$, then individuals with $u \leq \widehat{u}$ will be nonsmokers while individuals with $u > \widehat{u}$ will be smokers.[15] In the following, we define the *share of smokers* in the society as a function of $\widehat{u}$, namely

$$x(\widehat{u}) = \int_{\widehat{u}}^{\overline{u}} f(u)\mathrm{d}u = 1 - F(\widehat{u}). \tag{4}$$

Obviously, $x'(\widehat{u}) = -f(\widehat{u}) < 0$, i.e., the share of smokers is strictly decreasing in $\widehat{u}$. To find the indifferent individual

[12] We use a static approach in our model and focus on rational decisions. Addiction as a component of the individual smoking decision is implicitly included as some part of individual utility. Addiction models build on early analyses in which the individual's past consumption patterns affect present choices. See, for instance, Pollak [36] or Stigler and Becker [39]. However, addiction may be consistent with rational behavior as shown by Becker and Murphy [6]. For a detailed summary of the economic analysis of addictive consumption, the reader is referred to Pacula and Chaloupka [31].

[13] This assumption is without loss of generality. We use it in order to obtain an easy and intuitive interpretation of our results in later analysis.

[14] It should be noted that, to simplify the analysis, we study a representative disease (for instance, heart attack). The impact of a heart attack on an individual is measured by s. The events "a disease is caused directly by a an individual by smoking himself" (d) and "a disease is caused indirectly by secondhand smoke exposure" (a) are assumed to be independent. The probability of "disease occurs" in case of a smoker is then $\Pr(d) + \Pr(a) - \Pr(d \cap a) = p + qx - pqx = p + (1 - p)qx$ (see Eq. 1). In case of a nonsmoker, this probability is reduced to qx (see Eq. 2).

[15] We assume without loss of generality that an individual does not smoke if she is indifferent.

with utility $\widehat{u}$, we look at the individual's excess of expected utility

$$\Delta(x(\widehat{u})) = N(x(\widehat{u})) - S(x(\widehat{u}), \widehat{u}), \tag{5}$$

where

$$N(x(\widehat{u})) = h - qx(\widehat{u})s \tag{6}$$

and

$$S(x(\widehat{u}), \widehat{u}) = h + \widehat{u} - (p + (1-p)qx(\widehat{u}))s. \tag{7}$$

The excess of expected utility can be rewritten to

$$\Delta(x(\widehat{u})) = ps(1 - qx(\widehat{u})) - \widehat{u}. \tag{8}$$

Note that (a) at $\widehat{u} = 0$

$$\Delta(x(0)) = ps(1-q) > 0, \tag{9}$$

and (b) at $\widehat{u} = \overline{u}$

$$\Delta(x(\overline{u})) = ps - \overline{u} < 0, \tag{10}$$

so that (a) not smoking is always profitable given zero individual utility if everybody else smokes and the indirect risk is very high and that (b) smoking is always profitable under very high individual utility given nobody else smokes and thus zero indirect risk. Simplifying notation $\Delta(x(\widehat{u}))$ to $\Delta(\widehat{u})$ and assuming further that $\Delta'(\widehat{u}) < 0$, Eqs. 9 and 10 ensure the existence of a unique interior solution u^*, where $0 < u^* < \overline{u}$, for which $\Delta(u^*) = N(u^*) - S(u^*) = 0$.[16] The share of smokers in society, $x(u^*)$, is then implicitly given by

$$u^* = ps(1 - qx(u^*)), \tag{11}$$

where the marginal individual with utility u^* divides all individuals into a group of smokers and nonsmokers, respectively: Excess of expected utility is positive for $u < u^*$ and negative for $u > u^*$, so that individuals with utility $u \leq u^*$ are nonsmokers while those with utility $u > u^*$ are smokers. u^* may be interpreted as the (competitive) *Nash equilibrium* since it represents an outcome where every individual decides optimally given the others behave optimally.

Social welfare

Since our focus is on the secondhand smoking issue which is basically an externality problem, we look at social welfare in the sense of Kaldor-Hicks. Of course, tax revenues that attend Pigouvian corrections may be used by the government for redistribution in society. When a smoking ban is imposed, the result would be a decline in tax revenues, pursuant to a reduction in tobacco consumption. However, any such redistribution mechanism is irrelevant from a Kaldor-Hicks viewpoint, and we can thus abstain from these potential effects.

Due to smoking externalities, the unregulated situation will be inefficient from a social welfare viewpoint. To see this in our framework, consider social welfare $W(\widehat{u})$ in utilitarian fashion as simply the "sum" of utilities of all individuals:

$$W(\widehat{u}) = N(x(\widehat{u}))[1 - x(\widehat{u})] + \int_{\widehat{u}}^{\overline{u}} S(x(\widehat{u}), u) f(u) \mathrm{d}u. \tag{12}$$

Taking into account that $\mathrm{d}x(\widehat{u})/\mathrm{d}\widehat{u} = -f(\widehat{u})$, the first-order condition for an interior maximum of the social welfare function is

$$\begin{aligned} W'(\widehat{u}) &= [N(x(\widehat{u})) - S(x(\widehat{u}), \widehat{u})] f(\widehat{u}) + \frac{\mathrm{d}N(x(\widehat{u}))}{\mathrm{d}\widehat{u}} F(\widehat{u}) \\ &\quad + \int_{\widehat{u}}^{\overline{u}} \frac{\partial S(x(\widehat{u}), u)}{\partial \widehat{u}} f(u) \mathrm{d}u \\ &= \left[\Delta(\widehat{u}) + qs \cdot F(\widehat{u}) + \int_{\widehat{u}}^{\overline{u}} (1-p) qs f(u) \mathrm{d}u \right] f(\widehat{u}) = 0. \end{aligned} \tag{13}$$

Marginal social welfare is positive at $\widehat{u} = 0$ and negative at $\widehat{u} = \overline{u}$. Therefore, $W(\widehat{u})$ has a unique interior maximum at u^{**}, where[17]

$$u^{**} := \arg\max_{\widehat{u}} W(\widehat{u}). \tag{14}$$

$x(u^{**})$ represents the socially optimal share of smokers in the population. Taking a look at marginal social welfare $W'(\widehat{u})$ at u^*, we find[18]

$$W'(\widehat{u})|_{\widehat{u}=u^*} = \left[qs \cdot F(u^*) + \int_{u^*}^{\overline{u}} (1-p) qs f(u) \mathrm{d}u \right] f(u^*) > 0. \tag{15}$$

Social welfare is not optimal at u^* and Eq. 15 implies $W(u^{**}) > W(u^*)$. Indeed, the share of smokers is higher in the unregulated case than in the social optimum. This result is well known in public economics: (risk-)externalities

[16] The assumption $\mathrm{d}\Delta(\widehat{u})/\mathrm{d}\widehat{u} < 0$ implies $spq < 1/f(\widehat{u})$. It is for technical reasons only since it eliminates the possibility of more than one interior solutions in our model. Note that it is always fulfilled for a uniform distribution $(f(\widehat{u}) := 1/\overline{u})$. The possibility of multiple solutions, however, doesn't make any economic sense. We therefore focus on the reasonable monotonic cases.

[17] Note that the maximum is indeed unique since it is determined by condition $\Delta(\widehat{u}) + qs \cdot F(\widehat{u}) + [1 - F(\widehat{u})](1-p)qs = 0$ which can be rewritten to $\Delta(\widehat{u}) - [[1 - F(\widehat{u})]qps - qs] = 0$. The former expression is decreasing in $\widehat{u}$.

[18] Note that $\Delta(u^*)$ is zero.

imply market failure. Hence, an unregulated situation leads to a welfare loss in society because there are "too many" smokers.

Smoking bans versus Pigouvian taxation

A well-known solution to the externality problem is Pigouvian taxation that induces the socially optimal share of smokers determined by u^{**}. It is commonly reached by imposing a tax on the externality-generating activity: smoking. The optimal tax is determined in such a way that the indifferent individual has utility $\widehat{u} = u^{**}$. Many countries decided to enact more or less strict bans on smoking. The most strict ban is a perfect smoking ban. We call a *perfect smoking ban* a law prohibiting the purchase of cigarettes, i.e., a total ban corresponding to a 100% smoke-free environment. As a consequence, every other ban that is not a total ban is called a *partial smoking ban*. Such a partial ban is a law that restricts smoking in certain instances only, for instance, a work area ban in which smoking is allowed in some common areas. The usual argument against a perfect smoking ban is that a zero level of the externality-generating activity is, in general, not optimal.[19] Indeed, note that social welfare under a *perfect smoking ban* in our model becomes

$$W(\overline{u}) = \int_0^{\overline{u}} N(x(\overline{u}))f(u)\mathrm{d}u = N(x(\overline{u})) = h < W(u^{**}). \quad (16)$$

As a result, enacting a perfect smoking ban is associated with "too extreme" restrictions on smoking. It restricts the externality-generating activity in an inefficient way. However, a perfect ban might improve efficiency compared to the unregulated situation. As one might expect, this depends on the distribution of smoking utilities in the population.

While it is intuitive that—from a social welfare perspective—Pigouvian taxation is always superior to a perfect ban, this result may not carry over to a partial ban because externalities do not emerge evenly. Pigouvian taxation burdens all individuals with the same tax and cannot differentiate between location of tobacco consumption. From a pure theoretical viewpoint, it would be reasonable to impose a higher tax on cigarette consumption in restaurants, bars, and workplaces than for instance in a public garden. This is intuitive since externalities from smoking do not always spread in the same magnitude but are more severe in public venues.

Of course, it might be argued that a tax could vary by location, too, but this idea again seems difficult and very costly to implement in practice. Indeed, this seems to be particularly costly from a transaction cost viewpoint. For instance, it might be necessary to control hand bags for cigarettes when people enter a restaurant. Of course, traditional Pigouvian taxes do not work as efficiently as they should. Theoretically, differentiating taxes may achieve a first-best solution via different tax rates for different externalities. Then, there would be tax policies that control directly the secondhand smoking problem, and such taxes would be more efficient than or as efficient as partial smoking bans. However, establishing such a number of different tax policies is far from realistic, and an easier lump-sum approach seems more reasonable from an economic viewpoint.

Clearly, restrictions on smoking in public places, restaurants, bars, and private work sites impose additional costs on smokers by forcing them to smoke outdoors, thereby raising the time and discomfort associated with smoking. Taking into account this discomfort, we assume a constant disutility d for all smokers who are forced to smoke outdoors by a partial smoking ban. To ensure that the individual with very high smoking utility $\overline{u}$ still has positive utility under a partial ban, we suppose $d \in [0, \overline{u} - ps)$.

Indeed, whether Pigouvian taxation or a partial smoking ban is the better public health policy to improve efficiency in our society depends mainly on the size of externalities. A partial smoking ban is superior to Pigouvian taxation if the secondhand smoking externality differs sufficiently between locations of tobacco consumption. To see this, assume that a partial smoking ban reduces q to q_b, where $0 \leq q_b < q$. Social welfare under a partial smoking ban becomes then

$$W(\widehat{u}_b, d) = \int_0^{\widehat{u}} [h - q_b x(\widehat{u})s]f(u)\mathrm{d}u + \int_{\widehat{u}}^{\overline{u}} [h + (u - d) - (p + (1-p)q_b x(\widehat{u}))s]f(u)\mathrm{d}u,$$

and the (Nash) equilibrium is

$$u_b^* = d + ps(1 - q_b x(u_b^*)). \quad (17)$$

In the following, we show that under a relatively easy and intuitive condition, (1) enacting a partial smoking ban alone always improves social welfare (a) in an unregulated society and (b) even in a regulated society if externalities can be eliminated, and (2) it is ensured that a combination of Pigouvian tax and a partial smoking ban leads to a higher social optimum than implementing corrective Pigouvian taxation alone.

Proposition 1 *In an unregulated society (i.e., in a society where no Pigouvian tax is implemented), if secondhand smoking externalities differ sufficiently with respect to location (i.e., if $d < d_{crit.}$), or if disutility is zero, enacting a partial smoking ban always improves social welfare.*

[19] See Poutvaara and Siemers [37, p. 1510].

Proof Consider the difference $\Delta W(\widehat{u}, d) := W_b(\widehat{u}, d) - W(\widehat{u})$ which can be rewritten to

$$\Delta W(\widehat{u}, d) = x(\widehat{u})[(q - q_b)(1 - px(\widehat{u}))s - d]. \quad (18)$$

From Eq. 18 follows that $\Delta W(\widehat{u}, d)$ is always positive for any $\widehat{u} < \overline{u}$ as long as

$$(q - q_b) > \frac{d}{(1 - p)s} \quad (19)$$

holds, i.e., as long as the secondhand smoking externalities differ sufficiently with respect to location, or similarly,

$$d < d_{\text{crit.}} \equiv (q - q_b)(1 - p)s, \quad (20)$$

as long as the cost of the ban measured by discomfort d is lower than its benefit measured by $(q - q_b)(1 - p)s$. Applying the implicit function theorem to Eq. 11 gives $du^*/dq < 0$. Comparing then Eq. 17 to 11 implies $q_b < q \Rightarrow u_b^* > u^*$. Thus, u^* is smaller than u_b^*, so there are more nonsmokers after introducing a partial ban, and since similar to Eq. 15 $W'(\widehat{u_b}, d)|_{\widehat{u_b}=u_b^*} > 0$, we always must have

$$W(u_b^*) > W(u^*). \quad (21)$$

As a result, if externalities differ sufficiently so that Eq. 19 holds, a partial smoking ban always improves social welfare. □

Proposition 1 is illustrated in Fig. 1. The figure depicts social welfare before and after enacting a partial smoking ban under uniformly distributed smoking utilities in society.[20] Unsurprisingly, as can also easily be seen from Fig. 1 by comparing social welfare maxima before and after introduction of a partial smoking ban, two instruments are always better than one:

Proposition 2 *In a society where Pigouvian taxation is implemented, given the conditions of Proposition 1, combining a partial smoking ban with a corrective Pigouvian tax always leads to a higher social optimum (when compared to corrective taxation alone).*

Proof The proof is straightforward. Under the conditions of Proposition 1, $\Delta W(\widehat{u}, d)$ is always positive. So if Eq. 19 holds, combining a partial ban with corrective Pigouvian taxation leads to a higher social optimum than taxation alone and $W(u_b^{**}) > W(u^{**})$. In this case, the corrective Pigouvian tax needs to be implemented on q_b to ensure the social optimum under a partial smoking ban $(W(u_b^{**}))$. □

If a partial smoking ban can eliminate smoking externalities, we conclude the following

[20] In Fig. 1, we assume $h = 100$; $s = 60$; $p = 0.2$; $d = 5$; $q = 0.5$; $q_b = 0.2$ and $\overline{u} = 100$.

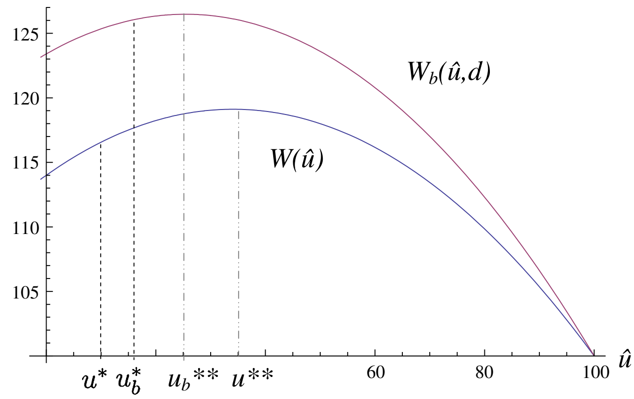

Fig. 1 Social welfare with and without partial smoking ban

Proposition 3 *No matter whether a society is regulated via Pigouvian taxation or not, if $q_b = 0$, a partial smoking ban always increases social welfare if $d < q(1 - p)s$.*

Proof In case $q_b = 0$, excess of expected utility becomes $\Delta(\widehat{u}) = ps + d - \widehat{u}$. This implies that under a partial smoking ban, we have $u_b^* = u_b^{**} = ps + d > u^*$ for all $d \geq 0$. This can be seen by taking a look at the derivative of the social welfare function

$$W'(\widehat{u}) = f(\widehat{u})[d - \widehat{u} + ps], \quad (22)$$

which is zero at $\widehat{u} = u_b^{**} = d + ps$. As a result, if the externality is reduced to zero so that $q_b = 0$ and there is no secondhand-smoke after imposing a ban, the resulting Nash equilibrium and welfare maximum are identical. Then, given $d < q(1 - p)s$, a partial ban always improves social welfare and $t_b^{\text{opt}} = 0$, i.e., no corrective taxation is needed. □

Our results concerning a comparison of Partial Smoking Ban (PSB), Nash Equilibrium (NE), and Pigouvian Taxation (PT) are summarized in Table 2. We conclude that a partial smoking ban is superior to Pigouvian taxation if (a) the externality can be reduced to (approximately) zero and (b) smokers' disutility is below their expected gain in health generated by the ban, i.e., if

$$q_b = 0 \quad \text{and} \quad d < q(1 - p)s. \quad (23)$$

A combination of smoking ban and Pigouvian tax will always improve welfare given the conditions above. Of course, such a combination is needless in case $q_b = 0$.

Is there a market solution?

Smoking bans might, at least in some circumstances, be dispensable when markets can solve the externality problem by establishing a separating equilibrium. For instance, a separating equilibrium may consist of some restaurants where owners prohibit smoking while others do not.

Table 2 Summary of results

	$d > 0$	$d = 0$
$q_b > 0$	$d < (q - q_b)(1 - p)s$: PSB superior to NE	PSB superior to NE
$q_b = 0$	$d < q(1 - p)s$: PSB superior to NE **PSB superior to PT**	PSB superior to NE **PSB superior to PT**

However, such a market solution cannot entirely solve the risk externality problem and is associated with additional costs for consumers. In more detail, the following arguments apply to such a market solution:

Firstly, a separating equilibrium is only suitable if individuals have the choice to avoid certain locations. While restaurant and bar smoking bans seem to be a good example for a potential separating equilibrium, workplaces and government agencies are not.

Secondly, a separating equilibrium does not solve the externality problem even in the case of bars and restaurants. It leads to a zero-externality from smokers to nonsmokers. However, within the group of smokers, there is still a positive externality. Thus, a separating equilibrium can only solve the first problem, i.e., the externality that is imposed by smokers on nonsmokers. The risk allocation problem within the group of smokers remains. A market solution in the form of a separating equilibrium can only be successful in solving the externality problem between the groups of smokers and nonsmokers but cannot solve the overall problem—which is the more realistic case and studied in our model. However, a separating equilibrium reduces the externality, since the secondhand smoking risk is less for smokers due to their direct risk of smoking. Thus, the optimal tax rate would indeed be decreased when one considers such a separating equilibrium due to the reduced externality.

Thirdly, a separating equilibrium causes additional costs. Assume that nonsmokers have spatial preferences where they want to spend their evening (for instance, the bar next door). Visiting not their favorite bar but another nonsmoking place instead is associated with transport cost t (t might represent the distance in miles to that other nonsmoking bar). Thus, nonsmokers will have to consider a detour to the next nonsmoking bar in town. Given that being a nonsmoker during the evening is associated with additional transport cost t due to the detour, the nonsmokers' expected utility Eq. 6 becomes

$$N(x(\widehat{u}), t) = h - qx(\widehat{u})s - t \tag{24}$$

and the Nash equilibrium is $u_t^* = ps(1 - qx(u^*) - t < u^*$ for all $t > 0$. This implies that high transport cost may lead individuals to hazard the consequences of secondhand smoke if t is high. If separation were costless and $t = 0$, markets could fight the problem by establishing a separating equilibrium. Then, smokers and nonsmokers would visit different places. One can imagine that this is relatively easy in a big city with many bars and restaurants available at close distance. However, when one looks at the country side, separation becomes costly and markets do not function perfectly any more. As a result, the establishment of a separating equilibrium depends on the costs of separation. Given sufficiently low transport cost t, nonsmokers will easily be allocated to nonsmoking areas, but as t increases, separation becomes more difficult.

We conclude that a separating equilibrium would reduce the externality problem considerably but cannot solve it. The secondhand smoking externality is decreased and remains only relevant within the group of smokers. As a result, the market must be imperfect in correcting the secondhand smoking problem. Assuming that governments have limited information, neither the market nor a government solution is a perfect measure to solve the problem.

Concluding remarks

Smoking bans are gaining widespread support in the European Union and other countries. Almost all European bans prohibit smoking in public places such as work sites, restaurants, and bars. We refer to these bans as *partial bans* as compared to p*erfect bans* where smoking is never allowed under any circumstances. Using a simple expected-utility framework, our analysis contributes insight into which public policy will be most effective in handling the secondhand smoking problem. Our analysis arrives at the following conclusions for public policy.

Although smoking bans may improve public health outcomes, they are associated with individual costs for smokers. Taking such costs into account, it is important to examine whether smoking bans alone are the most favorable public health policy to bring about individual and social benefits. While enacting a *perfect smoking ban* is always inferior compared to corrective Pigouvian taxation, this result does not necessarily carry over to a *partial smoking ban*. This is because externalities differ substantially according to location. Alternatively, one might consider introducing differentiable taxation, but this would lead to extremely high transaction cost issues. Introducing a partial smoking ban may produce a welfare improvement compared to Pigouvian taxation if externalities differ sufficiently between locations. While it is well known in public economics that Pigouvian taxation is an effective instrument in order to correct an externality-generated market failure, we show that a partial (smoking) ban or a combination of a partial (smoking) ban *and* corrective taxation can lead to an even higher social optimum than corrective taxation alone.

In summary, the potential benefit of enacting a partial smoking ban decisively depends on the relationship between the smokers' disutility from the ban and the reduction in externalities such a ban may produce. In contrast, the distribution of smoking utilities in a society seems to play a nonprominent role. In more detail, public policy makers are advised to decide about smoking bans as follows:

- If $q_b \simeq q$, i.e., if externalities do not differ substantially with respect to location, introducing a partial smoking ban makes no economic sense. In this case, corrective Pigouvian taxation is the best option to maximize social welfare.
- If $d < (q - q_b)(1 - p)s$ and $q_b > 0$, i.e., if externalities differ substantially with respect to location, enacting a partial smoking ban *might* improve social welfare. Then, combining a partial smoking ban with corrective Pigouvian taxation seems the most successful policy instrument: It is associated with an even higher social optimum than corrective taxation alone.
- If $d < (q - q_b)(1 - p)s$ and $q_b = 0$, i.e., if externalities are reduced to zero, enacting a partial smoking ban is superior to implementing a Pigouvian tax.
- If $d > (q - q_b)(1 - p)s$ and $q_b \geq 0$, corrective Pigouvian taxation is superior to a partial smoking ban.

It should be noted that the focus of this paper is on *health* externalities and not on *economic* externalities. It might be argued that smoking bans exert harm on restaurant and bar owners. Then, of course, these economic externalities should be included in an economic analysis of smoking bans. Most of the literature suggests that smoking bans exert no adverse effects on restaurant owners (see Glantz [15] as well as Craven and Marlow [8] or Melberg and Lund [27]). However, the overall economic effects of restrictive smoking laws seem to be complex [10]. Countries where smoking is banned in bars and restaurants tend to experience reductions in bar employment compared to countries that allow for smoking [1]. Marlow [26] uses empirical evidence from Ohio's recently adopted smoking ban. He finds that previous studies underestimated economic harm since these studies did not take into account noncompliance as an indicator of harm. Indeed, noncompliance data suggest that smoking bans impose economic harm on some bars, restaurants, and organizations. Bars probably suffer more harm than restaurants. A full accounting of the costs of individuals associated with bars and organizations should be weighed against any benefits—both economic and health—in research and debates over the desirability of smoking bans.

We have also neglected further beneficial or disadvantageous effects smoking bans might have on other markets or industries. For instance, Alamar and Glantz [3] find that contrary to claims made by opponents of smoking bans, these laws improve the market value of firms in the hospitality industry.

Finally, although the paper's focus is on smoking bans, our analysis and results might also apply to other externality problems. For instance, in order to improve air quality, some countries in Europe impose partial driving bans on high-emission vehicles in city areas (so-called environmental areas) where many people work and live. In Germany, for instance, Berlin, Cologne and Hannover have already established such city zones where pollutive cars are banned and only cars that fulfill air quality conditions are allowed. Several other German cities will soon follow this example. In view of the beneficial effects of enacting partial bans in a society where externalities differ sufficiently with respect to location, it seems fruitful to consider such bans as a potentially very successful public health policy to increase overall welfare.

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