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Smoking Bans in the Presence of Social Interaction

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Abstract

This paper analyzes the welfare effects of a public smoking ban in bars. We construct a model that captures crucial features of bar life: competing bars, social interaction, and heterogenous preferences for a smoking ban. Smokers and non-smokers simultaneously choose a bar given their preferences for meeting other people. Bars anticipate the behavior of individuals and choose the smoking regime strategically. Since the (dis)utility from smoking and social interaction are substitutes, the smoking regime is a stronger coordination device if the disutility from smoking is large. If all bars allow smoking in equilibrium, a public smoking ban enhances welfare.

Keywords: Smoking Ban, Social Interaction, Coordination Game
JEL: L13, I18, D61

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1 Introduction

In recent years, public smoking bans have been mushrooming in many countries all over the world. Smoking is typically banned in federal buildings, hospitals, schools, universities, and workplaces, among other public areas. In many states, smoking is also banned in restaurants, bars, and the like.

The motivation for policymakers to ban smoking in bars and restaurants is that it burdens a negative externality on non-smokers due to the severe health effects caused by second-hand smoke. Although this argument at first glance provides a profound justification for the ban, second thoughts about the issue also pose a puzzle, at least from an economist's point of view. The decision about whether or not to visit a bar should be based on the optimizing behavior of agents. If the negative effect of smoking exceeds the marginal gain of going out, agents should decide to stay at home or demand non-smoking restaurants. Moreover, if the marginal gain of smoking in a bar is large, bars should in fact be able to allow smoking. Thus, since there is a market for (potentially different) bar services, the smoking externality should either be internalized or there should be some kind of Coase mechanism that, again, would result in the optimal choice of the smoking regime. The latter argument, for example, is put forward by Boyes and Marlow (1996), who claim that a public smoking ban in bars is merely a distributive device without any allocation effect.

Before the implementation of smoking bans, the vast majority of bars and restaurants allowed their customers to smoke. As an example, this was true for 99.7% of Germany's 240,000 bars, cafés, and restaurants. According to the Coasian argument above, this should be the optimal allocation, and no public intervention should be needed. However, polls show that more than 60% of European citizens would like to see smoking banned in bars. It seems that there is demand for smoke-free places but no supply: an observation that is somewhat at odds with the claim that the unregulated allocation is efficient.

In this paper, we argue that the efficiency argument ignores an important aspect of the restaurant and bar choice of individuals: social interaction. Individuals enjoy meeting other individuals in bars. Thus, their bar choice is driven not only by the smoking regime of the particular bar (the strength of the negative externality) but also by the expected number of fellow guests. This coordination mechanism may result in lock-in effects and offers bars and restaurants a strategic device to gain a competitive advantage over other bars and restaurants. The bottom line of this coordination externality is that the decentralized choices do not necessarily resemble the Pareto efficient allocation.

To analyze the effects of a public smoking ban on the hospitality market, we construct a theoretical model that captures crucial features of bar life: competition among bars, social interaction among customers, and heterogenous preferences regarding smoking in a bar. To keep things simple, we separate individuals into two groups. *Smokers* retain a utility gain when smoking in a bar is allowed whereas *non-smokers* lose utility in this situation. In addition to the preferences regarding smoking, we add preferences for social interaction. That is, all individuals have a desire to meet with other individuals in bars. This social interaction motive implies a preference for the bar that attracts the highest expected number of guests. The idea is that a large number of customers raises the probability of meeting interesting individuals. The bars we consider are structurally identical (i.e., they are perfect substitutes given a common smoking regime). However, they can use the smoking regime to compete for customers. Bars ban or allow smoking to become more attractive to either smokers or non-smokers. Moreover, if individuals prefer company in a bar, the smoking regime choice can be used strategically to coordinate individuals on a bar. The smoking regime choice, hence, is not only used to meet the customers' preferences for smoke(ing), but also as a strategy to gain a competitive advantage. This may result in a trade-off, which is at the heart of our analysis.

We capture these features in a two-stage game where bars choose the smoking regime at the first stage. At the second stage, individuals choose "their" bar. Using backward induction, we solve the latter subgame for a mixed strategy Nash equilibrium. On the basis of this equilibrium, we compute the expected number of guests in each bar as a function of the smoking regime. Given these payoffs, we determine the profit-maximizing smoking regime choice of competing bars. The resulting strategies bring forth our main results. First, in equilibrium, bars will never choose different smoking regimes. Second, if both bars choose to allow smoking, a smoking ban enhances welfare in the hospitality market. These results are driven by the interplay of the social interaction motive and competition among bars. Utility maximization requires all individuals to be mutually indifferent between bars in expectations (this is captured by the Nash equilibrium in mixed strategies in the coordination subgame). This indifference is anticipated by each of the bars and, given the smoking regime choice of the competing bar, generates a tendency to allow smoking precisely in situations where the disutility from smoking among non-smokers is large relative to the utility gained by smokers from being allowed to smoke. From the point of view of a single bar (and holding the other bar's smoking regime fixed), the customers' unfavored smoking regime is then complementary to its expected number of guests. Accordingly, in this example where the disutility from smoking among non-smokers is large, allowing customers to smoke becomes a powerful coordination device. Turning to the choice of the social planner, we are able to show that the planner will always deviate from the decentralized smoking regime solution. This is due to the fact that the planner does not rely on the smoking regime as a coordination device, but uses it only to maximize customer's utility. Hence, a public smoking ban may enhance welfare.

There is only a little theoretical research into the economic effects of smoking bans on the hospitality market. In a very recent paper, Poutvaara and Siemers (2009) analyze the Nash equilibrium smoking regime outcome in a bar/restaurant given different social norms concerning the accommodation of smoking. They show that (depending on the social norm) there may be an inefficient smoking regime outcome. This could be used as an argument for a public smoking ban as a second-best policy although a Coasian solution would yield the first-best outcome. Our paper takes a different perspective on the problem since we do not focus on the limited situation of an exogenous meeting of a smoker and a non-smoker as they do. We allow for social interaction and consider a richer choice set of individuals: endogenous participation and choice of the smoking regime (the strategic variable of bars).

The majority of papers on smoking bans claim that there is no need for governmental interventions in the case of privately owned businesses like bars (see Tollison and Wagner, 1992, Lee, 1991, Boyes and Marlow, 1996, and Dunham and Marlow, 2000, 2003, 2004). In general, these studies do not provide a full-fledge theoretical framework but rest on the application of the Coase theorem. As long as property rights are well defined a welfare maximizing bargain between smokers and non-smokers is possible and no intervention is needed. Hence, a public smoking ban is inefficient and hinders bar owners in choosing the smoking regime that accomodates guests' needs.

The applicability of the Coase Theorem in the case of smoking bans, however, is at least debatable. Phelps (1992) for example opposed the full property rights approach earlier, claiming that "the transaction costs of reaching agreements would overwhelm the problem" (p. 430). We further conjecture that participation is likely to be endogenous since customers can choose unilaterally "their" bar. Hence, the Coase theorem may fail to hold (see, e.g., Dixit and Olson, 2000, on failures of the Coase theorem in games with endogenous participation). Finally, our paper points to the strategic nature of the smoking regime choice. Applying competition among bars and social interaction among customers, the paper provides a specific example where the allocation of property rights is used as a strategic device and thus no longer exclusively reflects individuals' preferences.

The remainder of the paper is organized as follows. Section 2 sets up the model and discusses the game structure. Section 3 solves the model, characterizes the equilibrium, and provides some intuition for the model's mechanics. Section 4 describes the equilibrium when a social planner dictates the welfare-maximizing smoking regime in the bars. A comparison of the market equilibrium and the planner solution proves our main results. Section 5 concludes.

2 The Model

Our model is completely described by individuals' preferences for going out, the bars' technologies, and the structure of the game. We describe each in turn.

2.1 Preferences

Individuals enjoy going out and meeting other bar customers. Consider a market where N^S smokers (for simplicity defined as individuals who smoke and appreciate smoking in a bar) and N^{NS} non-smokers (defined as individuals who do not smoke and dislike smoking in a bar) choose to either visit bar i or bar j.[1] The utility of a smoker and non-smoker from visiting bar i is

$$U_i^S = V^S + \gamma \left(n_i^S + n_i^{NS} - 1 \right) + \theta_i \alpha, \tag{1}$$

$$U_i^{NS} = V^{NS} + \gamma (n_i^S + n_i^{NS} - 1) - \theta_i \beta n_i^S, \tag{2}$$

[1] We use this classification to keep the interpretation straightforward. More generally, the two types of individuals can be thought of as smaller groups of individuals who as a group perceive that smoking in a bar comes at a net utility gain or loss, respectively.

where the three terms in each utility function capture the utility derived from consuming bar i's service, meeting other guests in bar i, and facing bar i's smoking regime choice, respectively. The first terms, the utility from bar services like food offers and drinks, are identical across bars, but may differ between smokers (V^S) and non-smokers (V^{NS}). The second terms reflect the desire for social interaction, which in our view is one of the primary reasons for visiting a bar. In particular, we assume "the more the merrier" preferences, i.e., the utility from visiting bar i increases in the total number of fellow guests in bar i, $n_i^S + n_i^{NS} - 1$, where n_i^S and n_i^{NS} denote the number of smokers and non-smokers in bar i, respectively. Hence, each customer who shows up in a bar exerts an externality on other customers. The third terms finally capture the impact of bar i's smoking regime choice (θ_i). If smoking is prohibited, the basic utilities from visiting bar i (i.e., ignoring social interaction) are equal to V^S and V^{NS} for smokers and non-smokers, respectively.[2] If smoking is allowed, in contrast, $\theta_i = 1$ and the basic utility from visiting bar i increases by α for each smoker, but decreases by βn_i^S for each non-smoker. The simple idea behind the non-smoker's utility loss is that it is determined by the amount of tobacco smoke in bar i, which in turn is an increasing function of the number of smokers in that bar.[3] Accordingly, the presence of a smoker is less advantageous to a non-smoker if smoking is allowed in the bar. In what follows, however, we concentrate on $\gamma > \beta$, i.e., the case where fellow smokers are overall "valuable" to non-smokers in any smoking regime.[4]

2.2 Bars

Bars supply food and drinks and provide a space to meet other individuals. By assumption, this service is produced at zero marginal costs. To keep the model concise, we further rule out any effects from choosing prices or the size of the bars strategically. The implicit assumption is that prices

[2]Our choice of V^S and V^{NS} as the basic utility obtained from visiting a bar that bans smoking is arbitrary. Equivalently, V^S and V^{NS} can be denominated in terms of a bar that allows smoking. Crucially, we require that each smoking regime choice benefits one group and disadvantages the other.

[3]Given the high costs of smoke abatement and real-world evidence, we ignore the bar's option to implement an effective smoke funnel technology.

[4]This parameter restriction is not essential for our findings. To guarantee the existence of an equilibrium, however, we exclude the non-generic case $\beta\gamma = N^S N^{NS} / \left(N^S + N^{NS} - 1\right)$.

are exogenously fixed above marginal costs, and bars being sufficiently large to eliminate possible crowding or queuing effects.[5] With this, bars simply choose the smoking regime dummy θ_i in order to maximize their (expected) number of guests.

2.3 Game Structure

The important features of the environment described so far are (i) when visiting either one of the two bars, each individual affects all other individuals' utility from going out and (ii) this externality is a function of the smoking regime in the bars. We continue to set up the model as a two-stage game. At the first stage, bars simultaneously choose the smoking regime. At the second stage, individuals simultaneously decide whether to visit bar i or bar j. Since, at the margin, individuals prefer the most popular bar, the simultaneous bar choice adds an important feature: (iii) when choosing "their" bar, individuals do not know which bar will be chosen by other (smoking and non-smoking) individuals. We consider optimizing individuals to randomize over their pure strategies to cope with this coordination problem.[6]

3 Market Equilibrium

Figure 1 illustrates the extensive form of the game. The top part depicts the first stage, where both bars simultaneously choose the smoking regime (the regime choice game). Below, any individual (labeled 1 in the figure) chooses the appropriate bar knowing its smoking regime. Simultaneously, all other individuals (2, 3 and so on) choose "their" respective bar knowing the smoking regime, but not knowing 1's bar choice (the coordination game). An equilibrium consists of the subgame perfect Nash equilibrium in the coordination game, i.e., a probability distribution for each individual that maximizes her expected utility given the optimal probability distribution chosen by all other individuals, and a smoking regime choice of each bar that maximizes

[5] For an analysis of the strategic price setting behavior, see Bauer and Lingens (2008).

[6] Note that since we solve a static game of complete information with simultaneous moves, there is no herding (like, e.g., in the example considered in Bikchandani et al. 1992 or Banerjee 1992). Arguably, herding effects would be interesting in their own respect (Does the smoking regime choice induce herding? If so, what is the direction of the herd?). Sticking to the simplest possible model, we leave this aspect for future research.

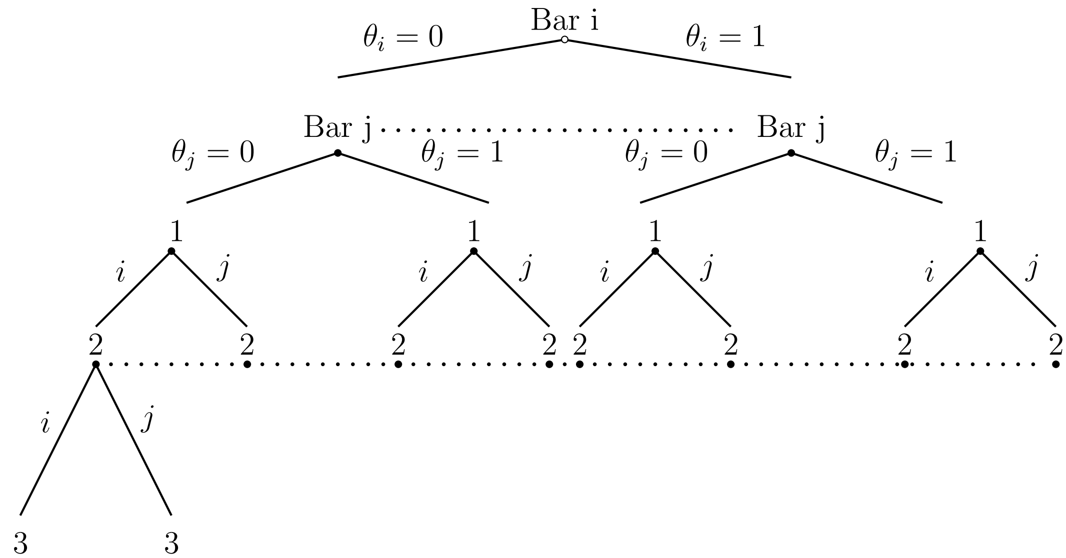

Figure 1: Extensive Form of the Smoking Regime Game

expected profits (i.e., the number of guests) given the equilibrium outcome of the coordination game. We solve the entire game by backward induction, starting with the coordination game.

3.1 Equilibrium in the Coordination Subgame

We obtain the mixed strategy Nash equilibrium in two steps. First, we derive separate conditions for smokers and non-smokers that leave an agent indifferent between the two bars given the randomization of all other agents. Second, we use the two resulting indifference relationships to calculate the equilibrium randomization of smokers and non-smokers.

3.1.1 Indifference of Non-Smokers

From the point of view of an agent who takes all other agents' decisions as given, the expected number of smokers and non-smokers in any bar is uncorrelated. Hence, the expected value of a non-smoker who decides to choose bar i is given by

$$\mathbb{E}(U_i^{NS}) = \sum_{n_i^S=0}^{N^S} \sum_{n_i^{NS}=0}^{N^{NS}-1} f(n_i^S) g(n_i^{NS}) \left(V^{NS} + \gamma(n_i^S + n_i^{NS}) - \theta_i \beta n_i^S\right), \quad (3)$$

where $\mathbb{E}$ denotes the expectation operator, $f(.)$ is the distribution function of the number of smokers, and $g(.)$ is the distribution function of the number of non-smokers. Similarly, the expected value of a smoker who chooses to visit bar i reads

$$\mathbb{E}(U_i^S) = \sum_{n_i^S=0}^{N^S-1} \sum_{n_i^{NS}=0}^{N^{NS}} f(n_i^S) g(n_i^{NS}) \left(V^{NS} + \gamma(n_i^S + n_i^{NS}) + \theta_i \alpha\right). \qquad (4)$$

Since both n_i^S and n_i^{NS} are binominally distributed (for a similar approach, see Dixit and Olson, 2000), equation (3) can be rewritten as

$$\mathbb{E}(U_i^{NS}) = V^{NS} + (\gamma - \theta_i \beta) P_i^S N^S + \gamma P_i^{NS} (N^{NS} - 1), \qquad (5)$$

where P_i^S and P_i^{NS} are the (yet to be determined) probabilities of a smoker and a fellow non-smoker, respectively, to visit bar i. Accordingly, a non-smoker is indifferent between bars i and j if $\mathbb{E}(U_i^{NS}) = \mathbb{E}(U_j^{NS})$, which, using the fact that $P_i^S + P_j^S = P_i^{NS} + P_j^{NS} = 1$, requires

$$((\gamma - \theta_i \beta) P_i^S - (1 - P_i^S)(\gamma - \theta_j \beta)) N^S = (1 - 2P_i^{NS}) \gamma (N^{NS} - 1),$$

where $\mathbb{E}(G_i) \equiv N^S P_i^S + N^{NS} P_i^{NS}$ denotes the expected number of guests in bar i. Collecting the probability terms on the left-hand side and denoting the expected number of guests in bar i by $\mathbb{E}(G_i) = N^S P_i^S + N^{NS} P_i^{NS}$, we obtain[7]

$$2\gamma \mathbb{E}(G_i) - \left((\theta_i + \theta_j) \beta N^S P_i^S + 2\gamma P_i^{NS} \right) = \gamma (N^{NS} - 1) + (\gamma - \theta_j \beta) N^S \equiv \phi_1. \qquad (6)$$

This indifference condition already reveals some important aspects of our model. Consider, e.g., a situation where bar i unilaterally deviates from the no-smoking regime ($\theta_i = 0$) and chooses to allow smoking ($\theta_i = 1$). Then, holding $\mathbb{E}(G_i)$ constant, the expected composition of smokers and non-smokers in bar i must adapt to keep a non-smoker indifferent. That is, with $\mathbb{E}(G_i)$ constant, the expected number of smokers in bar i must decrease, while the expected number of non-smokers must increase.[8] Alternatively, holding the composition of guests constant, the expected number of guests

[7] We introduce the additional endogenous variable $\mathbb{E}(G_i)$ because it allows a straightforward interpretation and proof of Proposition 2 below.

[8] This composition change is more pronounced if the externalities from smoking (β) are large or if the benefits from meeting others (γ) is small.

must increase. Allowing individuals to smoke is then an effective device to coordinate (both types of) individuals on bar i.

Condition (6) is a first equation that relates the (endogenous) probability choice of smokers and non-smokers, P_i^S and P_i^{NS} (recall that $\mathbb{E}(G_i) \equiv P_i^S N^S + P_i^{NS} N^{NS}$). A second equation in the same variables is readily derived from the indifference condition of the non-smokers. Performing analogous steps to the above yields

$$2\gamma\mathbb{E}(G_i) - 2\gamma P_i^S = \gamma(N^S - 1) + \gamma N^{NS} - (\theta_i - \theta_j)\alpha \equiv \phi_2. \tag{7}$$

The interpretation of (7) is very similar to that of (6). If bar i chooses the smoking regime ($\theta_i = 1$), the bar makes itself more attractive for smokers (hence, non-smokers are no longer indifferent either). In contrast to the non-smokers' case, however, the indifference of a smoker can only be restored by a lower expected number of guests in bar i. There is no composition effect since, for a smoker, fellow smokers and non-smokers are always perfect substitutes. Thus, from the point of view of bar i, the smoking regime is now a device to coordinate individuals on bar j.

The definition of $\mathbb{E}(G_i)$, (6), and (7) can be solved for $\mathbb{E}(G_i)$, P_i^S, and P_i^{NS} as a function of the smoking regimes θ_i and θ_j (i.e., the subgame perfect Nash equilibrium in the coordination game). To do so, we express the system of equations in matrix notation:

$$\underbrace{\begin{pmatrix} 2\gamma & -(\theta_i + \theta_j)\beta N^S & -2\gamma \\ 2\gamma & -2\gamma & 0 \\ -1 & N^S & N^{NS} \end{pmatrix}}_{\mathbf{A}} \begin{pmatrix} \mathbb{E}(G_i) \\ P_i^S \\ P_i^{NS} \end{pmatrix} = \begin{pmatrix} \phi_1 \\ \phi_2 \\ 0 \end{pmatrix}, \tag{8}$$

With this, we obtain the expected number of guests in bar i, the probability of a smoker visiting bar i, and the probability of a non-smoker visiting bar i in the coordination game equilibrium as

$$\mathbb{E}(G_i) = \frac{-2\gamma(N^S\phi_2 + N^{NS}\phi_1) + N^{NS}\phi_2(\theta_i + \theta_j)\beta N^S}{|\mathbf{A}|}, \tag{9}$$

$$P_i^S = \frac{2\gamma N^{NS}(\phi_2 - \phi_1) - 2\gamma\phi_2}{|\mathbf{A}|}, \tag{10}$$

$$P_i^{NS} = \frac{(\theta_i + \theta_j)\beta N^S\phi_2 + 2\gamma N^S\phi_1 - 2\gamma\phi_1 - 2\gamma N^S\phi_2}{|\mathbf{A}|}, \tag{11}$$

where the determinant of the coefficient matrix is given by $|\mathbf{A}| = 4\gamma^2(1 - N^S - N^{NS}) + 2\beta\gamma N^S N^{NS} (\theta_i + \theta_j)$.[9] The equilibrium reflects the ambiguous effects of a bar's smoking regime choice. At first, imposing a smoking ban makes the bar more attractive for non-smokers (and less so for smokers). The result, however, is an adjustment not only in the expected number of guests but also in the composition of guests. These adjustments influence again the relative attractiveness of the bar and hence the decisions of individuals.

3.2 Equilibrium

In this section, we characterize the equilibrium's properties. In particular, without loss of generality, we derive the smoking regime choice of bar i, which aims at maximizing the expected number of guests given the subgame perfect Nash equilibrium in the coordination game.

As a prerequisite, consider the situation where both bars choose identical smoking regimes, i.e. $\theta_i = \theta_j = \theta$. Imposing $\theta = 1$ and $\theta = 0$ in (9)–(11), respectively, proves

Lemma 1 *If both bars chose identical smoking regimes, the expected number of guests in each location is* $\mathbb{E}(G_i) = \frac{N^S + N^{NS}}{2}$. *In expectations, the fraction of smokers is equalized across the two bars* ($P_i^S = P_i^{NS} = .5$).

The intuition for this result is straightforward: with identical bars, both a smoking individual and a non-smoking individual are only indifferent between the two bars if every individual chooses each bar with probability .5. Since the mixed-strategy Nash equilibrium requires mutual indifference, this is the only equilibrium. Thus, it is expected that half of all individuals choose bar i. Keeping this finding in mind, we turn to the interesting question of which smoking regime is actually chosen by the two bars in equilibrium. As a first result, we rule out mixed smoking regimes.

Proposition 1 *In any Nash equilibrium, both bars choose the same smoking regime.*

Proof. By contradiction. Suppose that any mixed smoking regime choice, say $\theta_i = 1$ and $\theta_j = 0$, is a Nash equilibrium. Then, a unilateral deviation of bar i is not profitable. We thus have $\mathbb{E}(G_i[\theta_i = 1; \theta_j = 0]) \geq \mathbb{E}(G_i[\theta_i = 0; \theta_j = 0])$. This, however, directly implies $\mathbb{E}(G_i[\theta_i = 1; \theta_j = 0]) \leq \mathbb{E}(G_i[\theta_i =$

[9] The parameter restriction in footnote 4 ensures $|\mathbf{A}| \neq 0$.

$1; \theta_j = 1]$) (see the Appendix). Accordingly, bar j has an incentive to deviate and ($\theta_i = 1$, $\theta_j = 0$) cannot be a Nash equilibrium. Symmetry completes the proof. ■

We conclude from Proposition 1 and symmetry that either $\theta_i = \theta_j = 1$ or $\theta_i = \theta_j = 0$ are dominant strategies. The (non-)smoking regime provides a sufficiently strong coordination mechanism to prevent any bar from using its smoking regime as a differentiation device and run the risk of being identified as the "wrong" bar. Evidently, it depends on the parameter vector whether the "wrong" bar is a bar that bans or allows smoking. In particular, both bars will allow smoking if a unilateral deviation from the smoking regime results in less than $\frac{N^S+N^{NS}}{2}$ guests, i.e., if

$$\frac{\beta\gamma N^{NS}N^S + N^S\alpha(\beta N^{NS} - 2\gamma)}{|\mathbf{A}|} < 0 \tag{12}$$

$$\Leftrightarrow \frac{(1+\frac{\alpha}{\gamma})N^{NS} - 2\frac{\alpha}{\beta}}{2N^{NS} - 4\frac{\gamma}{\rho\beta}(1+\frac{1}{\rho} - \frac{1}{N^{NS}})} < 0, \tag{13}$$

where $\rho \equiv \frac{N^S}{N^{NS}}$ denotes the fraction of smokers relative to non-smokers (see the Appendix). While we require an explicit parameter vector to determine the equilibrium smoking regime, we can identify influencing variables that promote either one of the two smoking regimes. Quite intuitively, a large number of non-smokers (N^{NS}) and a pronounced aversion against fellow smokers (a large β) favors the smoke-free equilibrium. Similarly, smokers who value smoking not very much (so that α is small) promote the non-smoking regime. These direct effects originate from the fact that each smoking regime benefits one type of customers, but comes at a cost for the other type of customers. As indicated earlier, there are additional effects from social interaction and competition among bars. To begin with, if smoking is valued relative to meeting other people (such that α/γ is large), the smoking regime is *less* likely to occur in equilibrium. At first glance, this result is counterintuitive. If smokers have strong preferences regarding smoking in a bar, while not caring much about meeting others, why, then, should this favor the non-smoking equilibrium? The resolution rests at the heart of the Nash equilibrium in the coordination game, where utility maximization requires all agents to keep each other mutually indifferent between the bars. If smokers value smoking very much (relative to meeting others), they lean toward a bar that allows smoking. Now, if there is also a non-smoking bar, many individuals assign high probabilities to the non-smoking bar to keep the smokers indifferent. This reaction is strong since, in the case where α/γ is low, smokers do not value their fellow guests very much. With this, the smoke-filled bar is tempted to switch to a smoking ban to re-coordinate individuals and increase the bar's expected number of guests. Much in the same vein, if the social externality is large relative to the disutility of non-smokers from having fellow smokers in a bar that allows smoking (so that γ/β is large), the smoking regime is more likely to emerge in equilibrium. Starting from a situation where smoking is allowed in both bars, a deviating bar becomes somewhat more attractive to non-smokers. This reallocation, however, is weak as non-smokers view fellow smokers as good substitutes already under the smoking regime. Note, however, that there is again a counteracting effect that keeps smokers indifferent: more individuals will choose the smoking regime, hence deterring the initial deviation of the bar, and "stabilizing" the smoking regime. Finally, consider the effect from the fraction of smokers, ρ. Again, this effect is counterintuitive: a relative decline in the number of smokers strengthens the case for the smoking regime. The intuition here is that, in addition to the expected direct effect of allowing customers to smoke, there are two indirect coordination effects. On the one hand, a smoking ban increases the number of guests in the deviating bar to keep smokers indifferent. On the other hand, however, a smoking ban also increases the number of guests in the remaining non-smoking bar such that the non-smokers are indifferent. Once there are only a few smokers (relative to the number of non-smokers), the latter effect will overcompensate for the first effect. Then, a deviation is less likely to be profitable, fostering the smoking regime.

4 Social Planner – Welfare

In the previous section, we derived the Nash equilibrium in the case where bars competitively choose the smoking regime to maximize their expected number of guests. In this section, we contrast this market equilibrium with the choice of a social planner who takes the coordination friction among the individuals as given. Hence, the planner is not able to assign each individual to a bar, but can directly choose the smoking regime of the bars. This somewhat resembles the real-world situation where governments implement smoking bans. Given this environment, we ask whether a smoking ban enhances welfare if all bars choose to allow smoking in the market equilibrium. Solving the constrained planner's problem, we answer in the affirmative: imposing a smoking ban in our model enhances welfare.

To prove this result, consider first the planner's objective. The expected aggregate welfare is given by

$$P_i^S N^S \mathbb{E}(U_i^S) + P_j^S N^S \mathbb{E}(U_j^S) + P_i^{NS} N^{NS} \mathbb{E}(U_i^{NS}) + P_j^{NS} N^{NS} \mathbb{E}(U_j^{NS}). \quad (14)$$

Using the fact that $P_i^S + P_j^S = 1$, $P_i^{NS} + P_j^{NS} = 1$ and an individual's indifference between the two bars in the coordination game equilibrium (which boils down to identical expected utilities in both bars), (14) can be rewritten as

$$N^S \mathbb{E}(U_i^S) + N^{NS} \mathbb{E}(U_i^{NS}). \quad (15)$$

Plugging (4) and (5) in (15) and doing some manipulation, we obtain

$$W \equiv N^S V^S + N^{NS} V^{NS} + \gamma \mathbb{E}(G_i)(N^S + N^{NS} - 1) + \theta_i N^S \alpha - \theta_i N^{NS} \beta N^S P_i^S. \quad (16)$$

Expected aggregate welfare W thus consists of four parts: i) the basic utility of visiting either bar (V^S and V^{NS}), aggregated over all individuals; ii) the expected number of guests (which reflects the utility from social interaction) aggregated over all but one individual (which is due to the fact that social interaction excludes oneself); and, depending on the smoking regime iii) the smokers' aggregate utility from smoking or iv) the aggregate negative effect from smoking experienced by non-smokers.

Armed with the expression for aggregate welfare, we are able to answer two questions. First, what are the welfare consequences of implementing a strict smoking ban in a situation where all bars allow smoking in equilibrium (this basically resembles the situation in many OECD countries that chose to implement smoking bans)? Second, which smoking regime maximizes welfare?

Consider first the impact of a smoking ban if bars choose to allow smoking. We know that, given the equilibrium in the cooperation subgame, the expected number of guests is the same independent of whether both bars allow or ban smoking. Hence, choosing the smoking regime is profitable for bars once the negative smoking externality is large (and the utility gain from smoking is small) since this makes individuals choose the respective bar (in order to keep everybody mutually indifferent). In this situation, each bar chooses the smoking regime to coordinate individuals away from the other bar. The problem, however, is that both bars have this incentive. In the end, both bars are identical and welcome half of all individuals. We thus obtain the following Proposition.

Proposition 2 *If both bars choose to allow smoking in equilibrium, a public smoking ban enhances welfare.*

Proof. If both bars allow smoking in equilibrium, it must be that (12) holds, and, as shown in the Appendix, $N^S\alpha - N^{NS}\beta N^S P_i^S < 0$. Since $\mathbb{E}(G_i)$ is identical for both smoking regimes provided that $\theta_i = \theta_j$, this implies a negative welfare effect (cf. equation (16)), which can be "switched off" by imposing a smoking ban. ■

With the negative externality from smoking being very strong, each bar has the (wrong) incentive to allow individuals to smoke. While rational from each bars' point of view, the costs of this coordination are not matched by any welfare gain since the smoking regime choice of competing bars are strategic complements (cf. Proposition 1). Since bars end up being identical in equilibrium, the expected size of the social network in the "smoking regime" is identical to the expected size in the "smoke-free" equilibrium. The planner removes the negative externality from the strategic behavior among bars and implements the non-smoking regime.

We thus know that a general smoking ban increases welfare at least if smoking is allowed by both bars in the market equilibrium. We are left to answer our second question, namely to determine the smoking regime choice of the social planner. Hence, we now ask which smoking regime generates the largest welfare. Evidently, the optimal choice depends on the particular set of parameters. Independent of the parameter vector, however, the following holds.

Proposition 3 *The optimal smoking regime is never a mixed regime.*

Proof. Consider (without loss of generality) a situation in which $N^S\alpha - N^{NS}\beta N^S P_i^S < 0$. This implies that $W(\theta_i = \theta_j = 0) > W(\theta_i = \theta_j = 1)$. Due to symmetry, it is also true that $W(\theta_i = 1, \theta_j = 0) = W(\theta_i = 0, \theta_j = 1)$. Eventually, using equation (A.2), we can show that $W(\theta_i = \theta_j = 0) > W(\theta_i = 1, \theta_j = 0) > W(\theta_i = \theta_j = 1)$. ■

Similar to the profit-maximizing bars, the social planner does not want to implement a mixed smoking regime. In the market equilibrium, we have argued that no bar is willing to "help" individuals to coordinate. The reason the social planner is reluctant to choose the mixed regime, however, is somewhat different. Since the planner focusses on aggregate welfare, the allocation of individuals among bars is irrelevant (recall that the social interaction motive enters linearly). Thus, there is no role for "bar visitor smoothing". The planner is interested only in the negative smoking externality and the utility from smoking. If the smoking externality exceeds the utility from smoking, the planner bans smoking in every bar.

5 Conclusion

This paper argues that strategic incentives may pose an obstacle to the efficient allocation of air property rights, so that there is a case for publicly imposed smoking bans in bars. While our claim is more general, we exemplarily introduce "social interaction" as a friction on the demand side, i.e., individuals looking for other interesting individuals when going out. To prevent the first best, we assume that individuals randomize over their pure strategies when deciding which bar to attend. This implies that individuals solve a coordination game. In the preceding regime choice game, bars can either allow smoking or prohibit smoking and thus be more attractive to either smokers or non-smokers. We solve this two-stage game (the coordination game and the smoking regime choice) for a Nash equilibrium in mixed strategies in the coordination subgame and a Nash equilibrium in pure strategies in the smoking regime game. Since a bar with many customers offers high chances of meeting a suitable social partner, non-smoking individuals do not generally avoid bars where smoking is allowed. Each bar has an incentive to allow smoking if this attracts more smokers than it crowds out non-smokers. Competition among bars, however, rules out mixed smoking regimes (the smoking regime choice is strategically complementary). The intuition is that bars are not willing to help agents to coordinate since every bar might end up being the "wrong" bar. Hence, smokers and non-smokers are equally distributed among bars in equilibrium, and if air property rights are allocated to smokers, the utility loss of non-smokers outweighs the utility gain of smokers. With this, the model predicts that smoking bans, which have become ubiquitous in many countries, enhance welfare. The intuition is that individuals maximize utility by choosing the bars such that they are mutually indifferent (i.e., they solve the game for its mixed strategy Nash equilibrium). From each bar's point of view, there is thus an incentive to use the smoking regime as a coordination device. This is especially true in a situation where the cost (the negative externality from smoking) is large relative to the benefit (the additional utility from smoking) since, in this case, more individuals choose the smoking regime bar to compensate (through the social interaction) the negative net effect from smoking. The social planner does not need the use of a coordination device. If the costs exceed the benefit, the planner will ban smoking (and vice versa). We also show that the social planner will not choose mixed regimes either (in this regard, the market solution is efficient). This is because the planner does not care about the allocation of individuals between bars, but only about the net costs of smoking. If these are positive the planners bans smoking in all bars.

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Appendix

To rewrite the expected number of guests, we firstly collect the θ-terms in $N^S\phi_2 + N^{NS}\phi_1$ and $N^{NS}\phi_2(\theta_i+\theta_j)\beta N^S$. This gives

$$\begin{aligned} N^S\phi_2 + N^{NS}\phi_1 &= \gamma(N^S+N^{NS}-1)(N^S+N^{NS}) - (\theta_i-\theta_j)\alpha N^S \\ &\quad -\theta_j\beta N^S N^{NS}, \\ N^{NS}\phi_2(\theta_i+\theta_j)\beta N^S &= \theta_i\beta N^{NS}N^S\gamma(N^{NS}+N^S-1) \\ &\quad +\theta_j\beta N^{NS}N^S\gamma(N^{NS}+N^S-1) \\ &\quad -(\theta_i^2-\theta_j^2)\beta N^{NS}N^S\alpha. \end{aligned}$$

Using these expressions in (9), the expected number of guests in bar i becomes

$$\begin{aligned} \mathbb{E}(G_i) &= \frac{1}{|A|}(-2\gamma^2(N^S+N^{NS}-1)(N^S+N^{NS}) \\ &\quad +(\theta_i+\theta_j)\beta\gamma N^{NS}N^S(N^{NS}+N^S) + (\theta_j-\theta_i)\beta\gamma N^{NS}N^S \\ &\quad -N^S\alpha((\theta_i^2-\theta_j^2)\beta N^{NS} - 2\gamma(\theta_i-\theta_j)). \end{aligned}$$

Inserting the expression for $|A|$ and simplifying eventually gives

$$\begin{aligned} \mathbb{E}(G_i) &= \frac{1}{2}(N^S+N^{NS}) \\ &\quad +\frac{(\theta_j-\theta_i)\beta\gamma N^{NS}N^S - N^S\alpha((\theta_i^2-\theta_j^2)\beta N^{NS} - 2\gamma(\theta_i-\theta_j))}{4\gamma^2(1-N^S-N^{NS}) + 2\gamma N^S N^{NS}\theta_j\beta + 2\gamma N^S N^{NS}\theta_i\beta}. \end{aligned}$$

If both bars choose the same smoking regime $\theta_i = \theta_j$, each bar welcomes half of all individuals (smokers and non-smokers). Moreover, a parameter vector that gives

$$\mathbb{E}(G_i[\theta_i = 0; \theta_j = 1]) < \mathbb{E}(G_i[\theta_i = 1; \theta_j = 1])$$

directly implies

$$\mathbb{E}(G_i[\theta_i = 0; \theta_j = 0]) < \mathbb{E}(G_i[\theta_i = 1; \theta_j = 0]).$$

Welfare can be expressed as a function of the smoking regime in bar i or, equivalently, as a function of the smoking regime in bar j. Using (16) we thus have ($W - N^S V^S + N^{NS}V^{NS} =$)

$$\begin{aligned} &\gamma\mathbb{E}(G_i)(N^S+N^{NS}-1) + \theta_i N^S\alpha - \theta_i N^{NS}\beta N^S P_i^S = \\ &\quad \gamma\mathbb{E}(G_j)(N^S+N^{NS}-1) + \theta_j N^S\alpha - \theta_j N^{NS}\beta N^S P_i^S. \end{aligned} \tag{A.1}$$

Suppose e.g. that $\theta_i = 0$ and $\theta_j = 1$. Then, after substituting with the expressions for $\mathbb{E}(G_i)$ and $\mathbb{E}(G_j))$ from (9), (A.1) becomes

$$\gamma(N^S+N^{NS}-1)2\left(\frac{\beta\gamma N^{NS}N^S + N^S\alpha(\beta N^{NS}-2\gamma)}{|\mathbf{A}|}\right) = N^S\alpha - N^{NS}\beta N^S P_i^S. \tag{A.2}$$

Now, if both bars choose to allow smoking, it must be that a unilateral deviation from $\theta = 1$ results in less than $\frac{N^S+N^{NS}}{2}$ guests, i.e. (12) holds. Thus, (A.2) implies $N^S\alpha - N^{NS}\beta N^S P_i^S < 0$ if $\theta_i = \theta_j = 1$ in equilibrium.