Effect of Smoking Bans on Smoking during Pregnancy: Evidence from Germany*

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Abstract

We investigate the consequences of smoking ban introduction on smoking behavior of pregnant women, by exploiting regional differences in smoking bans over time and across states. Focusing on smoking bans in restaurant and bars, we estimate the effect of smoking bans on average cigarette consumption and smoking rate among pregnant women using a difference-in-differences approach. In a comprehensive dataset containing information on nearly all hospital births in Germany, we find that the introduction of smoking bans has a small but significant decreasing effect on average number of cigarettes smoked by pregnant women, whereas it has no effect on smoking rate. Considering regional differences in smoking ban implementation, we find that especially strict smoking bans have strong effects on decreasing smoking intensity, however partial smoking bans are less effective.

JEL classification: I12, I18

Keywords: Smoking during Pregnancy, Smoking Bans, Prevalence of Smoking, QA-procedure perinatal medicine, Difference-in-Differences

1 Introduction

Maternal smoking during pregnancy harms the unborn child's health and is strongly associated with birth weight reduction as well as fetal growth restriction. Mothers who smoke are at high risk of preterm delivery, stillbirth, and low birth weight birth, which are leading causes of death, disability, and disease among newborns (Almond et al., 2005). These adverse effects pose excessive costs on health care systems (Jacob et al., 2017, Kathleen Adams et al., 2002). It is therefore one of the key public health priorities of the WHO and many governments to reduce smoking prevalence and exposure to secondhand smoke of individuals, for example by smoke-free legislation and smoking bans in public places. However, most studies find no firm

*Data from quality assurance procedures pursuant to Section 136 of the German Social Code, Book Five (Sozialgesetzbuch, SGB V) of the Federal Joint Committee (Gemeinsamer Bundesausschuss, G-BA) were used for this study.

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evidence on the effectiveness of smoking bans on active smoking (e.g., Adda and Cornaglia, 2010, Anger et al., 2011, Jones et al., 2015).

This study tries to shed a light on smoking habits of pregnant women in Germany and evaluates how smoke-free legislation impacts their smoking behavior. Pregnant women are especially at risk when smoking, as they are not only harming themselves but substantially threaten the health of their unborn baby. Therefore, it is important to evaluate who is smoking during pregnancy, whether there are differences by federal states and especially focus on how different implementations of smoking bans across federal states in Germany influence smoking among pregnant women.

We exploit staggered implementation of state level smoking ban legislation to estimate its effect on pregnant women's smoking behavior, using recent data from the German quality assurance procedure perinatal medicine, including all births that occurred in German hospitals between 2004-2016. We pursue a difference in differences (DiD) approach and make use of variation in smoke-free policy details by federal states over time. For smoking bans, we focus on bans in restaurant and bars, which differ substantially in terms of strictness across states. Therefore, we classify smoking bans into to groups, strict and partial bans, to account for different levels of strictness. Partial smoking bans include all bans with exceptions, i.e. smoking pubs, separate smoker room, whereas strict smoking bans do not allow for exceptions and prohibit smoking in all restaurant and bars.

Our findings suggest a small but significant decreasing effect of smoking bans on smoking intensity, but no effect on prevalence. Controlling for years and state fixed effects, we find a decrease in average daily cigarette consumption among smoking pregnant women, which is stronger for strict bans than for partial bans. For strict smoking bans, we find a decrease of around 0.3 daily cigarettes, corresponding to a reduction of 4 packs of cigarettes during pregnancy. For partial bans, we only find a reduction of 0.05 daily cigarettes. Regarding smoking prevalence among pregnant women, smoke-free legislation show no robust effect. Overall, smoke-free legislation seems to be an effective mean to reduce amount of cigarettes smoked, but have no effect on smoking prevalence.

Since analysis of smoking behavior trends in federal states suggests that groups of states behave similar over time, we want to relax the time-constant heterogeneity assumption imposed by the DiD framework and allow for unobserved group heterogeneity to vary over time. Using a recently introduced grouped fixed effects estimator by Bonhomme and Manresa (2015), we find very similar effects of smoking bans on smoking intensity as in our main specification. Again, we find a decrease of around 0.3 daily cigarettes due to strict smoking bans. Regarding smoking prevalence results suggest, that unobserved factors within certain groups of states explain the overall smoking prevalence reduction.

Overall, smoking prevalence in Germany is declining, but since prevalence is especially increasing for younger women in childbearing age (aged 15-45) (Bergmann et al., 2008, Lampert et al., 2013), there is a need to evaluate trends in smoking during pregnancy and underlying mechanisms. Most western countries show declining smoking prevalence (Cnattingius, 2004), however, there are still a lot of smoking pregnant women and especially Germany shows high smoking prevalence (World Health Organization, 2015). For example 10.7% of pregnant women are smoking in the US in 2010 (Tong et al., 2013), 12.5% in Denmark (2010), 16.5% in Norway in 2009, and 6.9% in Sweden in 2008 (Ekblad et al., 2013). Compared to other countries, data availability on smoking during pregnancy in Germany is poor, since only a few surveys exist, that elicit smoking behavior (Kuntz and Lampert, 2016). Nevertheless, prevalence of maternal smoking during pregnancy in Germany has been studied using different data sources (Kuntz and Lampert, 2016, Kuntz et al., 2018, Scholz et al., 2013, Schneider et al., 2008) and studies agree on declining prevalence. We also find declining smoking prevalence among pregnant women, which drops from 13% (2004) to 7.6% (2016). Additionally, we analyze smoking intensity. For average cigarette consumption we find a reduction of 1.6 daily cigarettes, from 10.4 daily cigarettes in 2004 to 8.8 in 2016. However, both smoking prevalence and intensity differ substantially across states. For smoking prevalence, there is a profound North/South disparity, where Northern and Central German states show higher prevalence. Looking at smoking intensity, a West/East disparity is visible, where pregnant smokers smoke on average more cigarettes in West Germany.

The literature on effects of smoking bans on smoking behavior shows limited evidence for their effectiveness on active smoking (e.g. Adda and Cornaglia (2010) for the US, Anger et al. (2011) for Germany, Carpenter et al. (2011) for Canada, Jones et al. (2015) for UK). To our knowledge, this is the first study with emphasis on effects on smoking behavior of pregnant women in Germany, but the effect on the entire German population has been studies by Anger et al. (2011). Using a difference in differences approach, Anger et al. (2011) study the effect of smoking bans in Germany short after introduction of federal laws and focus on short term effects. They find that the introduction of smoke-free legislation in Germany did not change average smoking behavior within the whole population. However, they find effects on individuals that go out to restaurants and bars often, where individuals are both less likely to smoke and reduce smoking intensity after the introduction of the ban. Regarding differences by federal state, smoker who live in states with stricter bans in place show stronger reduction, which is also supported by our findings. A study by Kvasnicka et al. (2018) examines the effect of public smoking bans in Germany on hospitalization. They find smoking bans to be effective in preventing hospital admissions due to cardiovascular diseases and asthma, but do not evaluate active smoking behavior in detail. Hankins and Tarasenko (2016) study effects of smoking bans on neonatal health outcomes and maternal smoking behavior during pregnancy in the US. They find no effect of smoking bans on maternal smoking behavior or neonatal health outcomes. Jones et al. (2015) examine the effect of public smoking bans on smoking behavior in the UK, where no firm evidence on the effects of smoking bans on smoking can be found. Similar to most studies in the literature, we also find mixed evidence for the effectiveness of bans on active smoking.

Since our primary focus is on pregnant women and their smoking behavior, this study adds to the existing body literature on effects of smoking bans by moving the focus to a narrower, but very important subgroup of the population. Further, we evaluate long-term trends on the most comprehensive data set including all hospital births in Germany and shed a light on differences in smoking ban enforcement by federal state. Studying smoking in Germany is of special interest, since Germany is one of the high-income country with the highest smoking prevalence (World Health Organization, 2015) and smoking behavior in Germany has not been researched extensively.

In the next section, we give more details on smoke-free legislation in Germany. Section 3 describes the main data source and discusses the empirical strategy. In section 4, we present our findings and additional robustness checks, followed by a discussion of results in section 5.

2 Smoking Bans in Germany

Smoke-free policies were introduced starting from August 2007 to ban smoking from several public places (i.e., bars and restaurants, schools, hospitals) in all 16 German federal states in order to protect non-smokers from adverse effects of second-hand tobacco smoke. Baden-Wuerttemberg was the first state to introduce smoke-free legislation in August 2007 and by the end of August 2008, all states had introduced corresponding laws. However, policy details differ in terms of several exemptions by federal states (DEHOGA, 2008). A federal law introduced on September 01, 2007 regulates strict smoking bans in federal institutions and public transport, additionally the federal government raised minimum legal age for buying cigarettes from 16 years to 18 years in all of Germany (September 01, 2007). Details on smoking bans in all other areas lie within responsibility of each federal state, causing differences in introduction dates and strictness of smoking bans over time and federal state. Overall, German smoking bans were less comprehensive than smoking bans introduced in other countries and several exemptions applied. In states like Baden-Wuerttemberg, Berlin, Lower Saxony, and Rhineland-Palatinate, pubs can self-declare as "smoker pub", allowing people to legally smoke inside. There are only three states where currently a strict smoking-ban applies in restaurant and bars. In Bavaria the at that time most comprehensive smoke-free legislation of all German states was introduced on January 01, 2008. The enforcement of this strict ban, among other reasons, was made responsible for poor election results of the ruling party (CSU) in the 2008 Bavaria state election. Therefore, following the election, strict smoking bans were relaxed on August 01, 2009, leading to massive criticism by smoke-free initiatives, which eventually led to a referendum in 2010. The referendum was a success for the smoke-free initiatives and the comprehensive smoke-free legislation from 2008 was reintroduced on August 01, 2010. The strict smoking ban prohibits any smoking in restaurant, bars, pubs, and beer tents on local fairs. The state of Saarland changed their smoking-bans on July 01, 2010, which now excludes any exemptions for smoking bans in restaurants and bars, taking place after transitional arrangements at latest in December 2011. Lastly, North Rhine-Westphalia which had one of the loosest smoking-ban legislation of all federal states, enforced stricter rules starting from May 01, 2013.

For smoking bans, we focus on bans in restaurants and bars, since they differ markedly between states (see Table 1 for details). We classify smoking bans into partial smoking bans and strict smoking bans, where strict smoking bans means smoking ban without exceptions in place (after updated legislation in Bavaria, North Rhine-Westphalia, Saarland). Partial smoking bans include exceptions like separate rooms dedicated to smoking inside (i.e., Brandenburg, Hamburg) or smoking pubs (i.e. Baden-Wuerttemberg, Berlin). Data on smoking ban introductions are based on authors personal research in current and archived federal state

Table 1: Enforcement Dates of smoking-bans in Germany

Federal State	Enforcement of smoking ban	Updated (Restaurants & Bars)
Baden-Wuerttemberg	August 01, 2007	-
Bavaria	January 01, 2008	August 01, 2009 and August 01, 2010
Berlin	July 01, 2008	-
Brandenburg	July 01, 2008	-
Bremen	July 01, 2008	-
Hamburg	January 01, 2008	-
Hesse	October 01, 2007	-
Lower Saxony	November 01, 2007	-
Mecklenburg-West Pomerania	August 01, 2008	-
North Rhine-Westphalia	July 01, 2008	May 01, 2013
Rhineland-Palatinate	February 15, 2008	-
Saarland	June 01, 2008	December 01, 2011*
Saxony	February 01, 2008	-
Saxony-Anhalt	July 01, 2008	-
Schleswig-Holstein	January 01, 2008	-
Thuringia	July 01, 2008	-
Germany	September 2007	-

* Stricter smoking ban was enforced July 01, 2010, but transition period for certain exceptions ended December 01, 2011.
Note: Information on smoking ban introductions are based on authors personal research in current and archived federal state laws and overview provided by DEHOGA (2008).

laws and overview provided by DEHOGA (2008). More detailed information on smoking bans in Germany can be found for example in Anger et al. (2011) and Kvasnicka et al. (2018).

3 Data and Method

3.1 Data Basis

Our main data source is data collected on behalf of the Common Federal Commission of Germany (Gemeinsamer Bundesausschuss, GBA) for the purpose of quality assurance. Data driven quality assurance is routinely conducted in all of Germany to ensure transparency in care, medical and nursing quality (IQTIG, 2016). One area covered by the healthcare quality assurance system is obstetrics and neonatology. Data in the area of obstetrics and neonatology comprises all inpatient births in German hospitals. We analyze data between 2004 and 2016. By law, all deliveries in hospitals need to be documented by hospital staff. Overall, the data comprises nearly all births that occurred in Germany between 2004-2016.

The data contains socio-demographic information on the mother (i.e., age, nationality, employment status), detailed information on pregnancy care (i.e. number of prenatal examinations), and detailed information about the birth and health information on the newborn (i.e. birth weight, APGAR Score, crown-heel length). See Table 2 for an overview of mothers demographic information, pregnancy risk factors and infant characteristics of the study population. Information on smoking during pregnancy is elicited by obstetrician and mothers are asked to recall their average daily cigarette consumption during pregnancy. The availability of information on smoking is limited to data from years 2004-2016. We classify each mother as smoker, who reported smoking at least one cigarette per day during pregnancy.

Overall, the data of 2004-2016 comprises 8,844,029 births. Of those, 85% reported their smoking behavior in 2004, whereas it declines to a reporting rate of only 79% in 2016. The study population comprises all pregnancies with smoking information available, resulting in 6,915,824 births. Mean and standard deviations of characteristics of interest remain comparable to the overall population after filtering for availability of smoking information.

For analyzing effects of smoking bans on smoking behavior among pregnant women, we use additional data sources. We link the female population of each federal state[1] to the observations on federal state level and additionally use data on smoking ban enforcement dates (for details see Table 1).

Table 2: Sample Means and Standard Deviation for Smoker and Non-Smoker in quality assurance procedure Perinatal Medicine (2004-2016)

	Whole Population		**Smoker**		**Non-Smoker**	
Variables	Mean	SD	Mean	SD	Mean	SD
Mothers Demographic Information						
age	30.19	5.56	27.34	6.06	30.46	5.44
unmarried	0.14	0.35	0.26	0.44	0.14	0.34
employed	0.54	0.50	0.33	0.47	0.55	0.50
Country of origin: Germany	0.81	0.39	0.85	0.36	0.82	0.39
housewife	0.27	0.44	0.45	0.50	0.28	0.45
in training/ studying	0.03	0.17	0.05	0.22	0.03	0.16
unskilled worker	0.03	0.17	0.05	0.22	0.03	0.17
skilled worker etc.	0.32	0.47	0.23	0.42	0.36	0.48
highly skilled worker etc.	0.12	0.33	0.04	0.18	0.14	0.34
Pregnancy Risk Factors						
previous pregnancies	1.10	1.34	1.46	1.67	1.06	1.29
previous stillbirths	0.01	0.11	0.01	0.12	0.01	0.10
live-births	1.16	1.02	1.37	1.24	1.12	0.99
prenatal care visits	11.48	3.46	10.79	3.62	11.57	3.43
SSW first care visit	9.32	4.04	10.06	5.15	9.24	3.85
inpatient stay (days)	1.73	10.31	2.09	10.37	1.50	10.28
weight before pregnancy	68.45	15.05	69.39	16.82	68.28	14.79
weight before birth	82.30	15.32	82.52	16.88	82.29	15.07
high risk pregnancy	0.33	0.48	0.39	0.50	0.31	0.47
gestation length	39.28	2.17	39.06	2.08	39.34	2.17
cigarettes per day	1.01	3.59	9.53	6.37	0.00	0.00
Infant Characteristics						
male	0.51	0.50	0.51	0.50	0.51	0.50
birth weight	3324.89	599.75	3133.35	585.27	3345.99	594.50
5-min APGAR score	9.63	0.96	9.59	1.03	9.64	0.93
head circumference	34.69	1.94	34.22	1.85	34.74	1.91
length child	51.08	3.40	50.15	3.32	51.16	3.31
gestation length	39.28	2.17	39.06	2.08	39.34	2.17
Number of Observations	8,844,029		736,260		6,179,564	

We observe a clear downward trend in both smoking prevalence and smoking intensity (see Figure 1). In 2004, 13% of mothers who reported smoking information did report smoking more than one cigarette per day, whereas in 2016, only 7.6% of all reporting mothers smoked. The average number of cigarettes smoked by smoking women during pregnancy declined from 10.4 in 2004 to 8.81 in 2016 (see Figure 1).

[1]Source: Fortschreibung des Bevölkerungsstandes (EVAS-Nr. 12411), Bevölkerung nach Geschlecht - Stichtag 31.12. - regionale Ebenen [2004-2016]. Statistische Ämter des Bundes und der Länder, 2021.

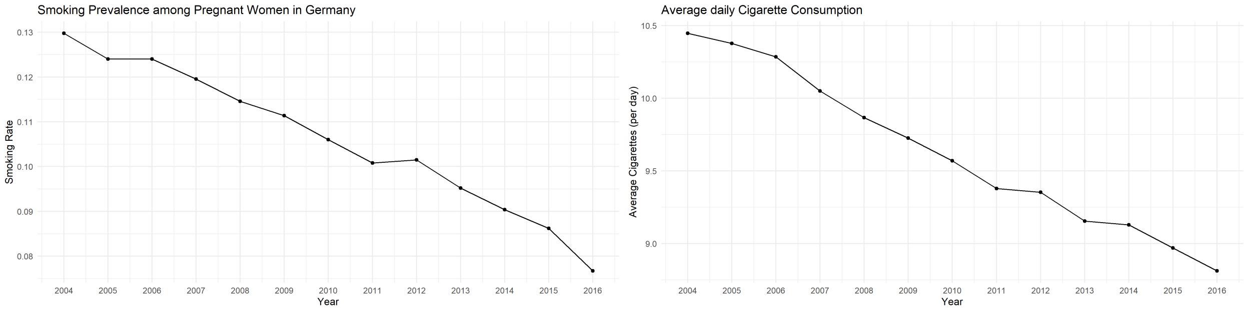

Figure 1: Smoking prevalence (left) and average daily cigarette consumption (right) of pregnant women in Germany between 2004-2016

Comparing smokers to non-smokers, we find that smoking pregnant women are on average younger than non-smoker, more likely to be single and more likely to be of German origin than non-smokers (see Table 2). Smoking pregnant women are usually less educated and less likely to be employed than non-smoking mothers. Women who smoke during pregnancy have on average 0.5 pregnancies more than non-smoking women. Further, there are differences in utilization of prenatal care. Smoking pregnant women start their pregnancy care on average later than non-smokers and attend less prenatal care visits throughout their pregnancy, even though the percentage of high-risk pregnancies is higher for smokers than non-smokers. Their inpatient stay at the hospital after birth is on average 0.59 days longer than for non-smoker.

There are strong regional differences by federal state in smoking prevalence among pregnant women in Germany (see Figure 4). There seems to be a North/ South separation when looking at smoking prevalence. In northern and central Germany, the smoking rate among pregnant women is higher than in southern Germany. In 2004, especially for Saxony-Anhalt there is a high smoking prevalence of 21.5%. Other northern regions show prevalence of around 15%. Only in southern Germany, there are lower smoking rates among pregnant women of below 10%. This difference fades over the 13 observed years but is still observable in 2016. This is especially interesting, since studies like Cnattingius (2004) on the overall smoking prevalence of young women report a West/East difference, whereas we find a North/South separation.

Regarding the average number of cigarettes smoked per day, one can see a profound West/East disparity (see Figure 5). Smoking pregnant women in West Germany smoke more daily cigarettes than those in the former East German regions. For Bavaria and Baden-Wuerttemberg we see lower average cigarette consumption, too. In 2004, the highest average daily cigarette consumption was reported in the Saarland (11.9 cigarettes per day), whereas the lowest average daily cigarette consumption was reported in Saxony (8.4 cigarettes per day). Over the 13 years of interest, average daily cigarettes smoked decline and difference between federal states fades.

Figure 2 shows, that average number of daily cigarettes smoked by smoking pregnant women follows the same downward trend in most federal states of Germany. For Bremen, a federal state with relatively small population, we observe unstable trends. But also for Brandenburg we see an increase in average cigarette consumption after 2012, getting close to the all-time high in 2007. For Mecklenburg-West Pomerania, we observe a sharp decrease in average cigarette consumption after 2014.

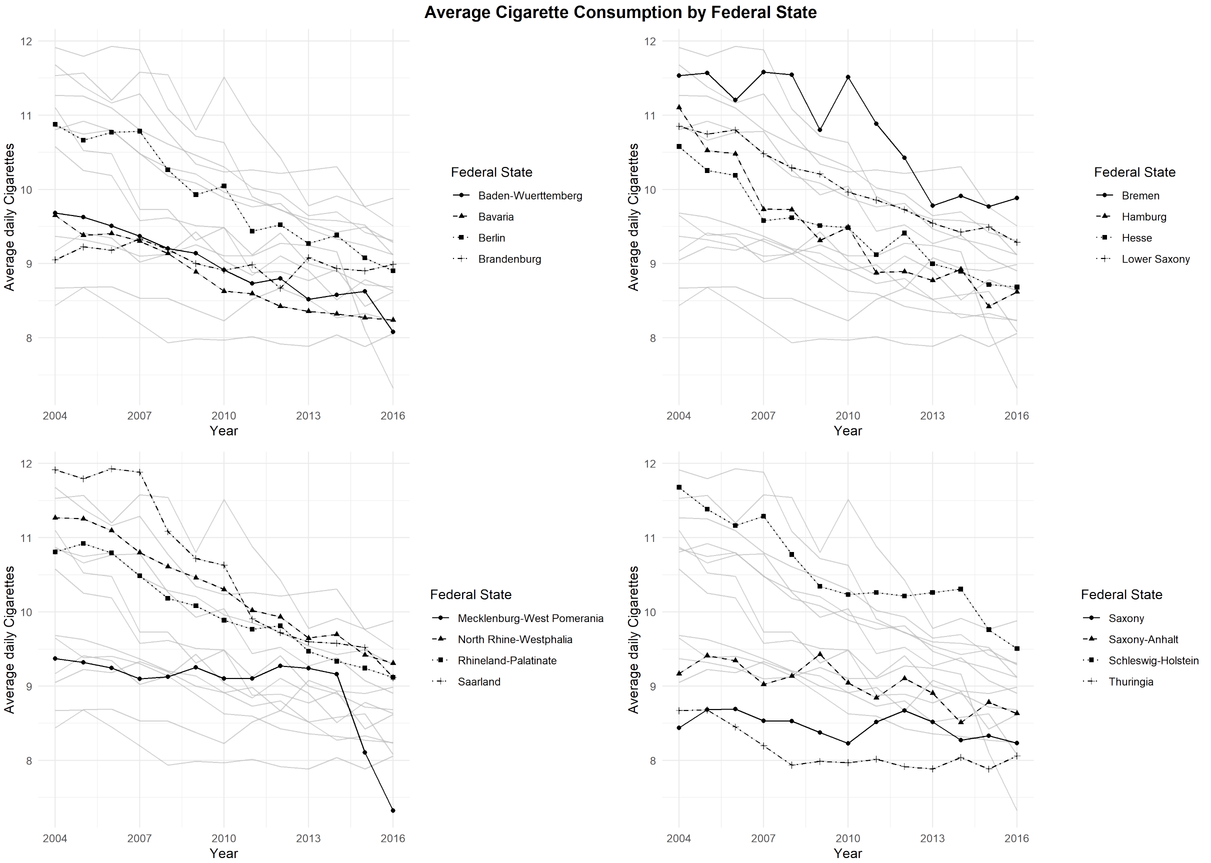

Figure 2: Average daily cigarette consumption by Federal State

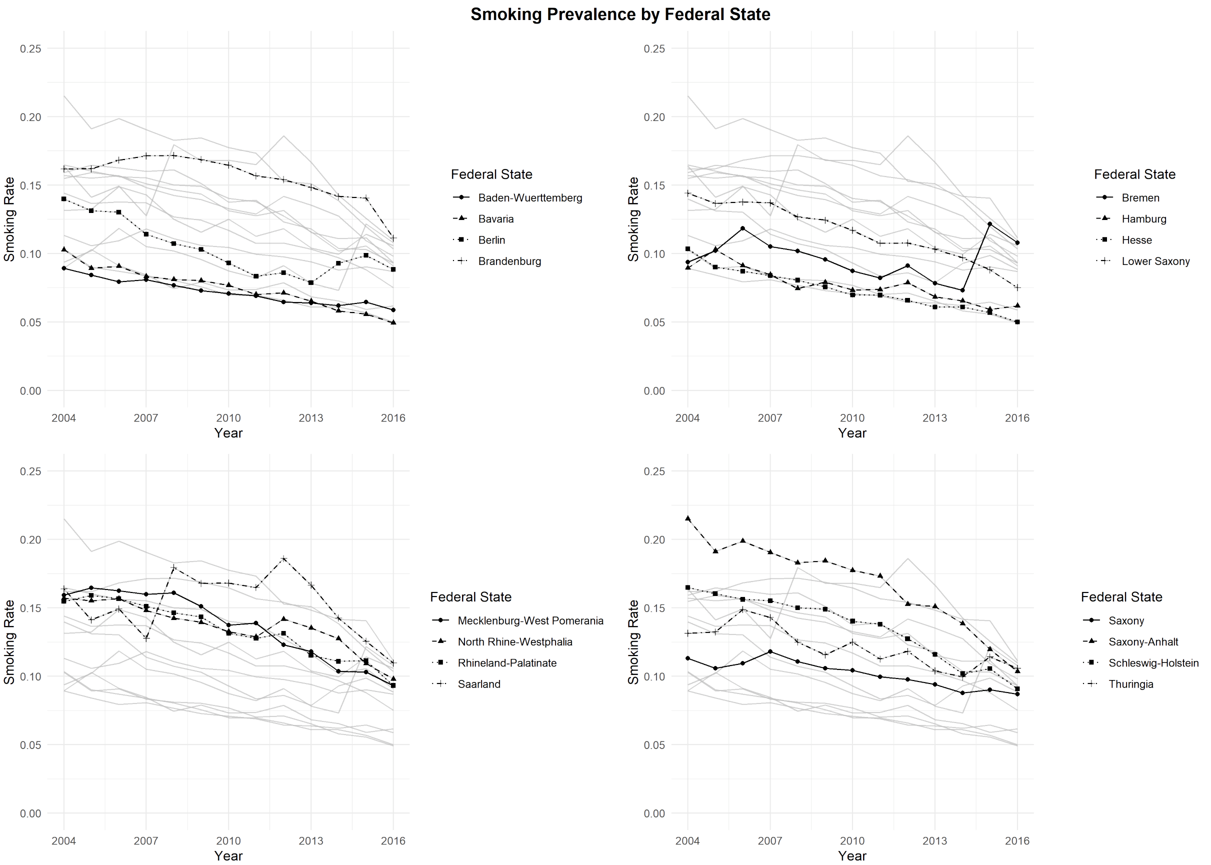

Figure 3: Smoking Rate by Federal State

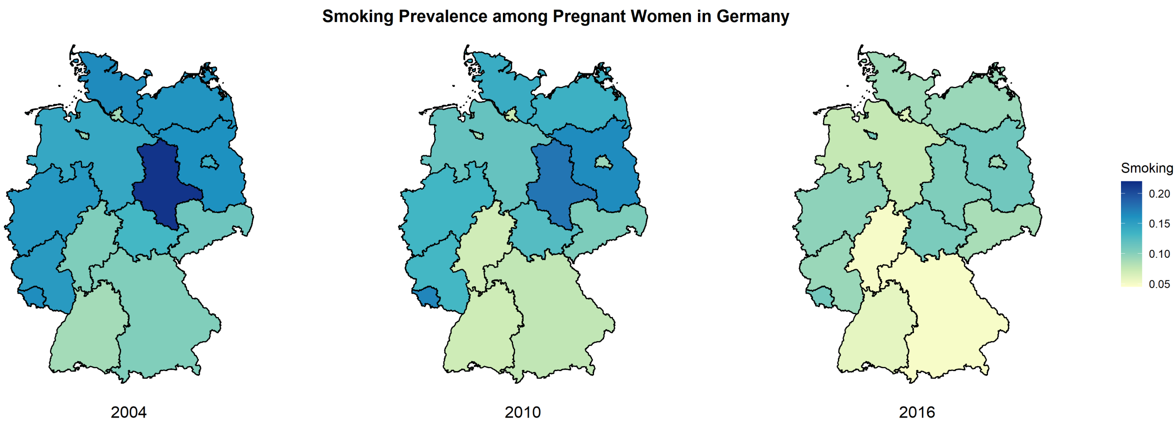

Figure 4: Smoking prevalence of pregnant women by federal state in Germany (2004, 2010, 2016)

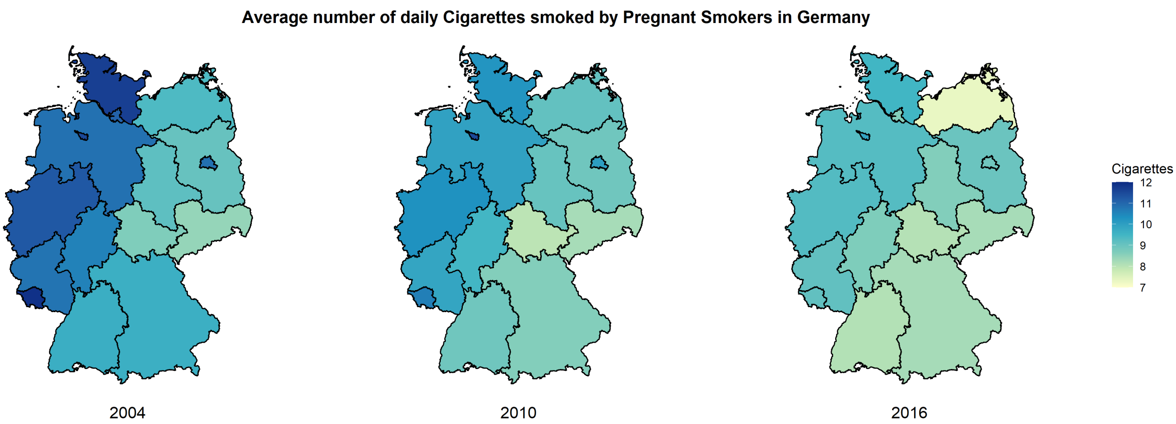

Figure 5: Average number of daily cigarettes smoked by federal state in Germany (2004, 2010, 2016)

Figure 3 shows strong differences in smoking rate between states. Especially for states with small population, like Saarland or Bremen, we observe unstable trends. For Saarland, we see a sharp increase in smoking rate in 2008, for Bremen we observe a sharp increase in 2015, despite the steady downward trend observed in the years before. Therefore, weights of population share are needed to evaluate effects of smoking bans in the next section.

3.2 Method

In order to estimate effects of smoking bans on average cigarette consumption and smoking rate among pregnant women, we exploit staggered implementation of smoking bans over time and over the 16 federal states using a difference-in-differences approach. Since we observe smoking behavior on a yearly basis, we approximate the introduction date of a new smoking ban regulation with the actual year of introduction. So, for the introduction of the smoking ban legislation on federal level (Nichtraucherschutzgesetz) on September 01, 2007, we would assume introduction starting in 2007. For legislation on federal state level, we focus on smoking bans related to restaurants and bars, since those differ strongest between the 16 states over time. We model smoking behavior as

$$\text{Smoking}_{st} = \beta_0 + \beta_1 \text{StrictBan}_{st} + \beta_2 \text{PartialBan}_{st} + \gamma_s + \mu_t + \epsilon_{st}, \tag{1}$$

where Smoking_{st} is either smoking rate among pregnant women or average cigarette consumption among smoking pregnant women in year t and federal state s. The parameters of interest are β_1 and β_2, the effect of introduction of strict smoke-free legislation StrictBan_{st} or partial smoke-free legislation PartialBan_{st} in federal state s at time t, respectively. In our identification, we include fixed effects to absorb confounding variation. γ_s, federal state fixed effects, control for unobserved heterogeneity in smoking behavior in federal states of Germany. Year fixed effects μ_t eliminate unobserved differences in smoking behavior in the years of interest and control for price changes. Since we observe smoking behavior on federal state level and not on individual level, we weight our observations by share of female population in each federal state to control for unstable trends in federal states with very small population (i.e., Saarland, Bremen).

4 Results

4.1 Smoking Ban and Smoking Behavior

We focus on smoking bans in restaurants and bars and estimate their effect on smoking rate and average cigarette consumption among pregnant women. Since smoking bans are implemented by federal states independently (Table 1) and legislation differs not only in enforcement date, but also in terms of strictness, we can estimate the effect of the introduction of state level legislation using a difference in differences approach.

The results for the effect of smoking ban introduction on smoking rate are presented in Table 3. Controlling for state fixed effects only, we find similar effects of partial smoking bans and strict smoking bans. Strict smoking bans seem to reduce smoking rate by 2 percentage points, the reduction of partial bans is only 1 percentage point. Both estimates are significant at the 1% level. Including years fixed effects, estimates are cut in half and appear insignificant. In our richest specification, including both state and year fixed effects, estimates on both ban types change sign and are positive, but insignificant. This change in sign suggests, that the estimates are not robust to different model specifications. Further, we cannot find enough evidence that decline in smoking rate is driven by smoking ban introduction in any way.

Table 4 shows the results for average number of cigarettes as outcome of interest. Regardless of the specification, we find a negative effects of both strict and partial smoking bans on average number of cigarettes smoked. Only including state fixed effects, the estimated effects are quite large and highly significant for both bans. Strict smoking bans reduce number of cigarettes smoked by more than one daily cigarette, the effect of partial ban is -0.63. Including years fixed effects, the size of the estimates reduces sharply and estimates are not significant. The estimate for strict bans reduces to -0.33 and the one for partial ban reduces even further to -0.09. In our richest specification, including both state and year fixed effects, the effect size is comparable to results when only including year fixed effects. This time, only the estimate on strict smoking bans is significantly different from zero.

Our results suggest that smoking bans mainly have an effect on the intensive margin and do not succeed in reducing the extensive margin, as they seem to have no effect on smoking rate, but significantly reduce the number of daily cigarettes pregnant women smoke. This mechanism is intuitive, since smoking bans reduce occasions to smoke in everyday life, particularly when going out, which might not lead to people quitting smoking overall, but reducing their consumption. Reduction in smoking rate, however, seems like a long-run trend, independent of the introduction of smoking bans.

Table 3: Effect of Introduction of federal state smoking bans in restaurant/bars (starting from 2007) on smoking rate among pregnant women

Dependent Variable:	Smoking Rate		
Model:	(1)	(2)	(3)
Variables			
Strict Smoking Ban	-0.0267***	-0.0148	0.0042
	(0.0041)	(0.0168)	(0.0032)
Partial Smoking Ban	-0.0159***	-0.0058	0.0042
	(0.0049)	(0.0114)	(0.0030)
Fixed-effects			
state	Yes		Yes
year		Yes	Yes
Fit statistics			
Observations	208	208	208
R^2	0.84620	0.21031	0.95469
Within R^2	0.35511	0.01551	0.01530

Clustered (state) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table 4: Effect of Introduction of federal state smoking bans in restaurant/bars (starting from 2007) on cigarette consumption among pregnant women

Dependent Variable:	Average Cigarettes		
Model:	(1)	(2)	(3)
Variables			
Strict Smoking Ban	-1.119***	-0.3302	-0.2865**
	(0.1969)	(0.3368)	(0.1047)
Partial Smoking Ban	-0.6263***	-0.0851	-0.0524
	(0.1348)	(0.1970)	(0.0577)
Fixed-effects			
state	Yes		Yes
year		Yes	Yes
Fit statistics			
Observations	208	208	208
R^2	0.82955	0.33631	0.94540
Within R^2	0.55751	0.01713	0.08267

Clustered (state) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

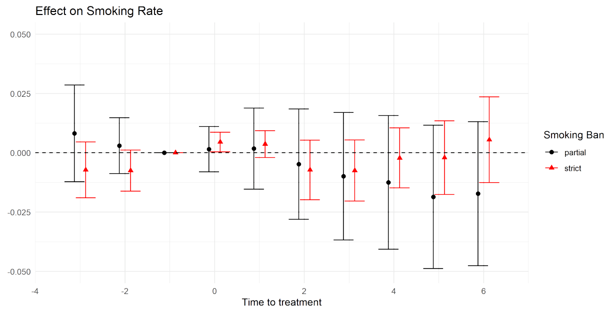

Figure 6: Event study for smoking rate

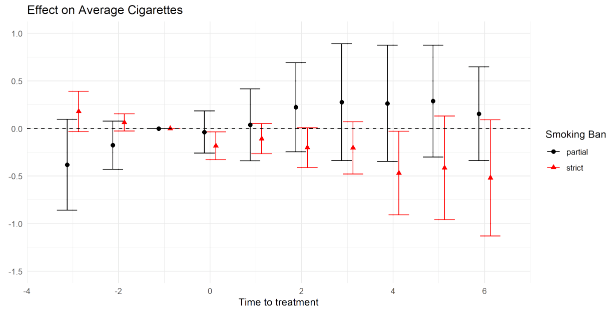

Figure 7: Event study for average cigarette consumption

4.2 Robustness Checks

To further evaluate treatment dynamic and check pre-treatment periods for balance between treatment and control group, we conduct an event study. We interact time dummies for the years before and after smoking ban introduction with the treatment indicators. Formally, we introduce several leads and lags of treatment in our main specification (1) and estimate

$$\text{Smoking}_{st} = \sum_{\substack{\tau=-3 \\ \tau\neq-1}}^{6} \alpha_\tau \mathbb{1}_{[t-\text{Strict}_s=\tau]} + \sum_{\substack{\tau=-3 \\ \tau\neq-1}}^{6} \beta_\tau \mathbb{1}_{[t-\text{Partial}_s=\tau]} + \gamma_s + \mu_t + \epsilon_{st}, \tag{2}$$

where Strict_s, Partial_s are the event dates, on which treatment status switches from 0 to 1 for the strict treatment or the partial treatment, respectively.

Focusing on smoking rate among pregnant women, no estimates in the two pre-treatment periods of interest appear to be significant (see Figure 6). Similarly, after introduction of treatment effects remain insignificant and close to 0. Effects appear positive in some periods after treatment introduction for both partial and strict bans. The event study shows that even after treatment introduction there is no significant effect on smoking rate.

Figure 7 shows the event study for the effect of smoking bans on average cigarette consumption. We find slightly positive, but insignificant estimates in the pre-treatment periods for strict smoking bans. Partial smoking bans show negative and insignificant effects in the pre-treatment periods. After treatment introduction, estimates for strict bans are considerably below zero and negative effects are significant in at least some years of interest, especially in the short run. The point estimates for partial bans are positive and increasing after treatment introduction, but insignificant.

Both event studies support plausibility of the common trends assumption and show negative effects of strict smoking bans on average cigarette consumption, especially shortly after treatment introduction. Effect of bans on smoking rate seems to be non-existent.

Since two-way fixed effects estimation might not be optimal to capture effects of smoking bans on smoking behavior due to the restrictive assumption of time-constant unobserved heterogeneity, we want to allow for unobserved group heterogeneity varying over time in our specification. The analysis of trends of smoking in federal states revealed differences in the evolution of smoking behavior over time across certain groups of states, which we hope to capture by group specific time trends. Additionally, the assumption of time varying unobserved group heterogeneity seems especially plausible in the case of Germany, where we have certain groups of states, that historically evolve similarly over time. For example, even years after German reunification, structural differences between federal states in the former GDR and West Germany remain.

We will make use of a novel grouped fixed effects (GFEs) estimator proposed by Bonhomme and Manresa (2015). GFEs cluster individuals with similar unobserved characteristics into a finite number of groups. Group assignments are not picked by the researcher. Rather, group assignment is data driven, by minimizing a least squares criterion over all possible groupings. GFEs assume that states within the same group share the same time profile of group-specific unobserved heterogeneity,

$$\text{Smoking}_{st} = \beta_1 \text{StrictBan}_{st} + \beta_2 \text{PartialBan}_{st} + \alpha_{g_s t} + \epsilon_{st}, \tag{3}$$

where $\alpha_{g_s t}$ refers to the time profile of group g_s for $g_s \in \{1, \ldots, G\}$. Since $\alpha_{g_s t}$ captures the groups' time trajectories, we exclude time fixed effects from the model. By defining a parameter $\theta = (\beta_1, \beta_2)$ and a vector of regressors $x_{st} = (\text{StrictBan}_{st}, \text{PartialBan}_{st})$, we can rewrite equation 3 more compactly

$$\text{Smoking}_{st} = x'_{st}\theta + \alpha_{g_s t} + \gamma_s + \epsilon_{st}. \tag{4}$$

The grouped fixed effects estimator is the solution of the following minimization problem

$$(\hat{\theta}, \hat{\alpha}, \hat{\gamma}) = \underset{\theta, \alpha, \gamma}{\operatorname{argmin}} \sum_{s=1}^{N} \sum_{t=1}^{T} (\text{Smoking}_{st} - x'_{st}\theta - \alpha_{g_s t})^2, \tag{5}$$

where we search for the minimum over all possible groupings $\gamma = \{g_1, \ldots, g_N\}$, common parameter θ and group-specific time effects α. For details on computation refer to Appendix A. GFEs also allow for individual specific time invariant fixed effects. In our setting, we will therefore add federal state fixed effects and estimate

$$\text{Smoking}_{st} = \beta_1 \text{StrictBan}_{st} + \beta_2 \text{PartialBan}_{st} + \alpha_{g_s t} + \gamma_s + \epsilon_{st}. \tag{6}$$

To not impose too many restrictions on the model, we will make use of either 2 or 3 groups for the GFEs. In practice, we first estimate the group assignment for each state and outcome for a given number of groups and interact this group assignment with time.

Figure 8 shows the group assignment for both outcomes of interest using two or three groups, respectively. The group assignment captures the North/South disparity in smoking rate when using two groups, where smoking prevalence is higher in the northern part of Germany (blue), than in the South (red). For three groups, we find a low prevalence group (green), a mid-prevalence group (red) and states with high prevalence (blue). Groups for average cigarettes smoked also reflect East/West disparity, as observed before. For two groups, we find a high-intensity smoking group for western parts of Germany (blue) and a low intensity

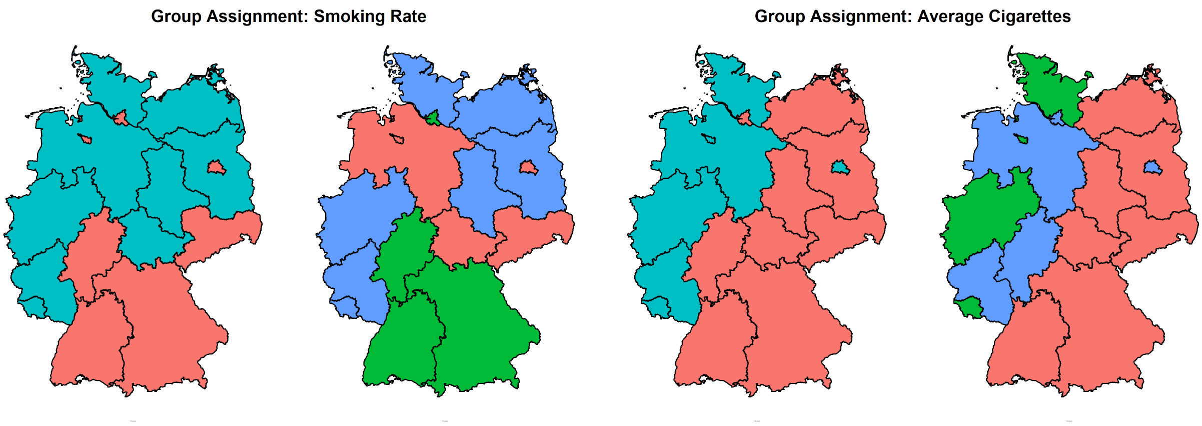

Figure 8: GFE group assignment for smoking prevalence (left) and average daily cigarette consumption (right).

smoking group for east and southern Germany (red). Considering three groups, high intensity states are marked in green, mid-intensity is marked in blue and low intensity in red, which again comprises most of the former East Germany and southern Germany states. Groups loosely reflect former GDR and West Germany differences as hypothesized before, especially with regard to average number of cigarettes smoked.

Table 5: Grouped Fixed Effects: Effect of Introduction of federal state smoking bans

Dependent Variables:	Smoking Rate		Average Cigarettes	
Model:	(1)	(2)	(3)	(4)
Variables				
Strict Smoking Ban	0.0085*	0.0092*	-0.2151***	-0.3110**
	(0.0041)	(0.0050)	(0.0650)	(0.1105)
Partial Smoking Ban	0.0045***	0.0041**	-0.0013	0.0246
	(0.0014)	(0.0015)	(0.0588)	(0.0772)
Fixed-effects				
state	Yes	Yes	Yes	Yes
sr_GFE_2-year	Yes			
sr_GFE_3-year		Yes		
ac_GFE_2-year			Yes	
ac_GFE_3-year				Yes
Fit statistics				
Observations	208	208	208	208
R^2	0.96955	0.96901	0.95980	0.96893
Within R^2	0.05721	0.05598	0.06609	0.11791

Clustered (state) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Allowing for unobserved patterns of heterogeneity, we find that the effect of smoking bans on average number of cigarettes smoked among pregnant women is comparable to the one found in our main specification. Strict smoking bans significantly reduce average number of cigarettes smoked by -0.22 or -0.31 daily cigarettes, depending on the number of groups used for clustering. Effect size does not differ a lot between different model specifications. Partial bans do not seem to have a robust effect of smoking intensity, since estimates vary in sign and are not significant. Using GFEs, we find positive significant effects of bans on smoking rate. The estimates for the effect of smoking bans on smoking rate, suggest that partial as well as strict bans increase smoking rate among pregnant women by around 0.9 percentage points. Given a baseline smoking rate in 2004 of around 13, this increase is fairly large. Reduction in smoking rate over time is therefore not attributable to introduction of smoking bans, but to other unobservable factors common to certain groups of states.

5 Discussion

Data from the quality assurance procedure obstetrics and quality assurance procedure neonatology suggests, that there is a declining trend in smoking during pregnancy. However, underlying mechanism that lead to smoking reduction remain unclear. Therefore, we evaluate the effect of smoke-free legislation in Germany that differ across state and over time to estimate their effect on smoking behavior of pregnant women. Pregnant women are a group of special interest, since they do not only harm themselves, but their unborn baby while smoking.

Starting from 2007, German federal states introduced laws to protect non-smokers, which ban smoking from public transport, restaurants, and public places. Those laws differ in strictness by federal state. We exploit these time and state varying differences, to provide causal estimates of the effect of the introduction of smoking bans on smoking behavior of pregnant women.

We find significant but small reduction effects on average cigarette consumption among pregnant women due to the introduction of smoking bans, but no such effect on smoking rate. Considering the effect of smoking bans on smoking intensity, we find that especially strict bans decrease smoking throughout pregnancy by 4 packs. This effect proves robust to different assumptions and model specifications. However, the effect of bans on smoking prevalence remains unclear, as different specifications and model assumptions lead to substantially different estimates. Therefore, this study suggests that smoking bans mainly work on the intensive margin and not the extensive margin, as they seem to have no clear effect on smoking rate, but significantly reduce the number of daily cigarettes pregnant women smoke.

To our knowledge this study is the first to evaluate the effect of smoking bans or smoke-free legislation on the smoking behavior of pregnant women. Previous studies assessing the effects of smoking bans on smoking behavior, mostly with focus on the entire population, also find mixed results of smoking bans on active smoking (Anger et al., 2011, Jones et al., 2015). However, certain subgroups seem to respond differently to smoke-free legislation than others, i.e. Anger et al. (2011) find decreasing effects on both smoking rate and cigarette consumption for individuals that go out often.

Since adverse effects of smoking are widely known and especially pregnant women are informed about harmful effects of smoking on their child, they might have an intrinsic willingness to stop smoking or at least reduce their cigarette consumption. This willingness is most probably higher than among the normal population, and therefore pregnant women might respond differently to smoking bans than other population groups. Especially strict smoking bans, which are currently in place in Saarland, North Rhine-Westphalia and Bavaria prove to be effective in reducing smoking intensity among pregnant women. Similarly, Anger et al. (2011) find that smokers living in states with stricter smoke-free legislation reduce smoking more than those living in states with more relaxed bans.

However, the results on declining smoking prevalence and also our estimates need to be considered with care. For most studies including this one, smoking during pregnancy is a self-reported measure, meaning that mothers do not need to admit to smoking during pregnancy. In Germany, smoking during pregnancy is socially unaccepted, therefore mothers might fear negative consequences when admitting to smoking during pregnancy. Bergmann et al. (2008) find overall decreasing trends in smoking, however it is increasing among young women. Therefore, Bergmann et al. (2008) assume strong underreporting for smoking during pregnancy, since most studies report significantly lower smoking rates even at the beginning of pregnancy, where they should be at least comparable to those in the childbearing age group. Similarly, Fleitmann et al. (2010) assume strong underreporting when it comes to smoking during pregnancy. Therefore, our results may only act as a lower bound for the effect of smoking bans on smoking during pregnancy due to underreporting issues.

As this study has shown, smoking prevalence during pregnancy is declining, and especially strict smoking bans enforce lower cigarette consumption among pregnant women. This effect of bans on smoking behavior found, might only hold true for the special subgroup of interest, but it indicates, that in order to enforce smoking cessation or reduction in cigarette consumption in the general population, stricter smoking bans in all of Germany might need to be considered.

References

Adda, Jérôme and Cornaglia, Francesca (2010). "The effect of bans and taxes on passive smoking". In: *American Economic Journal: Applied Economics*, 2(1):pp. 1–32.

Almond, Douglas, Chay, Kenneth Y., and Lee, David S. (2005). "The Costs of Low Birth Weight". In: *The Quarterly Journal of Economics*, 120(3):pp. 1031–1083.

Anger, Silke, Kvasnicka, Michael, and Siedler, Thomas (2011). "One last puff? public smoking bans and smoking behavior". In: *Journal of Health Economics*, 30(3):pp. 591–601.

Bergmann, R., Bergmann, K., Schumann, S., Richter, R., and Dudenhausen, J. (2008). "Rauchen in der schwangerschaft: Verbreitung, trend, risikofaktoren". In: *Zeitschrift für Geburtshilfe und Neonatologie*, 212(03):pp. 80–86.

Bonhomme, Stéphane and Manresa, Elena (2015). "Grouped patterns of heterogeneity in panel data". In: *Econometrica*, 83(3):pp. 1147–1184.

Carpenter, Christopher, Postolek, Sabina, and Warman, Casey (2011). "Public-place smoking laws and exposure to environmental tobacco smoke (ets)". In: *American Economic Journal: Economic Policy*, 3(3):pp. 35–61.

Cnattingius, Sven (2004). "The epidemiology of smoking during pregnancy: Smoking prevalence, maternal characteristics, and pregnancy outcomes". In: *Nicotine & Tobacco Research*, 6(Suppl_2):pp. S125–S140.

DEHOGA (2008). *Nichtraucherschutzgesetze in den Bundesländern. Synopse zu den Landesgesetzen.* Deutscher Hotel- und Gaststättenverband (DEHOGA), Berlin, Germany.

Ekblad, Mikael, Gissler, Mika, Korkeila, Jyrki, and Lehtonen, Liisa (2013). "Trends and risk groups for smoking during pregnancy in Finland and other Nordic countries". In: *European Journal of Public Health*, 24(4):pp. 544–551.

Fleitmann, S., Dohnke, B., Balke, K., Rustler, C., and Sonntag, U. (2010). "Frauen und rauchen". In: *Bundesgesundheitsblatt - Gesundheitsforschung - Gesundheitsschutz*, 53(2):pp. 117–124.

Hankins, Scott and Tarasenko, Yelena (2016). "Do smoking bans improve neonatal health?" In: *Health Services Research*, 51(5):pp. 1858–1878.

IQTIG, Institut für Qualitätssicherung und Transparenz im Gesundheitswesen (2016). "Qualitätsreport 2016".

Jacob, Josephine, Lehne, Moritz, Mischker, Andrea, Klinger, Normen, Zickermann, Claudia, and Walker, Jochen (2017). "Cost effects of preterm birth: a comparison of health care costs associated with early preterm, late preterm, and full-term birth in the first 3 years after birth." In: *The European journal of health economics : HEPAC : health economics in prevention and care*, 18:pp. 1041–1046.

Jones, Andrew M., Laporte, Audrey, Rice, Nigel, and Zucchelli, Eugenio (2015). "Do public smoking bans have an impact on active smoking? evidence from the uk". In: *Health Economics*, 24(2):pp. 175–192.

Kathleen Adams, E., Miller, Vincent P., Ernst, Carla, Nishimura, Brenda K., Melvin, Cathy, and Merritt, Robert (2002). "Neonatal health care costs related to smoking during pregnancy". In: *Health Economics*, 11(3):pp. 193–206.

Kuntz, B. and Lampert, T. (2016). "Social disparities in maternal smoking during pregnancy". In: *Geburtshilfe Frauenheilkd*, 76(03):pp. 239–247. 239.

Kuntz, Benjamin, Zeiher, Johannes, Starker, Anne, Prütz, Franziska, and Lampert, Thomas (2018). "Smoking during pregnancy. results of the cross-sectional kiggs wave 2 study and trends". In: *Journal of Health Monitoring*, 3(1):pp. 45–51.

Kvasnicka, Michael, Siedler, Thomas, and Ziebarth, Nicolas R. (2018). "The health effects of smoking bans: Evidence from german hospitalization data". In: *Health Economics*, 27(11):pp. 1738–1753.

Lampert, Thomas, Von Der Lippe, Elena, and Müters, Stephan (2013). "Verbreitung des rauchens in der erwachsenenbevölkerung in deutschland". In: *Bundesgesundheitsblatt-Gesundheitsforschung-Gesundheitsschutz*, 56(5-6):pp. 802–808.

Schneider, S., Maul, H., Freerksen, N., and Pötschke-Langer, M. (2008). “Who smokes during pregnancy? an analysis of the german perinatal quality survey 2005”. In: *Public Health*, 122(11):pp. 1210–1216.

Scholz, R., Voigt, M., Schneider, K. T. M., Rochow, N., Hagenah, H.-P., Hesse, V., and Straube, S. (2013). “Analysis of the german perinatal survey of the years 2007-2011 and comparison with data from 1995-1997: Maternal characteristics”. In: *GebFra - DGGG-Gesellschaftsausgaben*, (04):pp. 1247–1251. 1247.

Tong, Van T., Dietz, Patricia M., Morrow, Brian, D’Angelo, Denise V., Farr, Sherry L., Rockhill, Karilynn M., and England, Lucinda J. (2013). “Trends in smoking before, during, and after pregnancy — pregnancy risk assessment monitoring system, united states, 40 sites, 2000–2010”. In: *Morbidity and Mortality Weekly Report: Surveillance Summaries*, 62(6):pp. 1–19.

World Health Organization (2015). *WHO global report on trends in prevalence of tobacco smoking 2015*. World Health Organization.

Appendix

A Group Fixed Effects

To minimize 5, we make use of an interative algorithm proposed by Bonhomme and Manresa (2015). Given a fixed number of groups, chosen by the researcher, we use an iterative algorithm consisting of an assignment and an update step, which are repeated until numerical convergence. The algorithm for GFE assignment is very similar to the well-known clustering algorithm kmeans.

Algorithm 1: GFE estimator - Iterative:

For a given number of groups $g \in \{1, \ldots, G\}$:

1. Set random starting value $(\theta^{(0)}, \alpha^{(0)})$, $i = 0$.
2. Compute for all $s \in \{1, \ldots, N\}$:

$$g_s^{(i+1)} = \underset{g}{\text{argmin}} \sum_{t=1}^{T} (\text{Smoking}_{st} - x'_{st}\theta - \alpha^{(i)}_{g_s t})^2$$

3. Compute

$$(\theta^{(i+1)}, \alpha^{(i+1)}) = \underset{\theta,\alpha}{\text{argmin}} \sum_{s=1}^{N} \sum_{t=1}^{T} (\text{Smoking}_{st} - x'_{st}\theta - \alpha_{g_s^{(i+1)} t})^2$$

4. Set $i = i + 1$ and repeat until convergence.