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Michael Kvasnicka[1]

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Abstract

Tobacco control policies have proliferated in many countries in recent years, in particular youth access laws and public smoking bans. The effectiveness of youth access laws is still disputed, however, as are the costs of public smoking bans to the hospitality industry. Using a unique data set on cigarette sales at more than 100k vending machines that provides first objective evidence on the outgoing and customer behavior of smokers, we study both outcome dimensions by investigating several recent tobacco control measures in Germany. We find a large negative effect on cigarette sales of a nation-wide introduction of devices for electronic age verification in cigarette vending machines, particularly at machines placed outdoors and in localities that are strongly frequented by youths. In contrast, there is no evidence that a country-wide smoking ban in federal buildings affected cigarette sales in these premises and only weak evidence that a recent rise in the minimum legal smoking age affected cigarette purchases by youths. Finally, state-level smoking bans appear to have reduced indoor sales of cigarettes at vending machines, especially in bars. However, the magnitude of the estimated effect is rather modest, suggesting that businesses in the hospitality industry are unlikely to have been affected severely.

JEL Classification: I18, K32, L51

Keywords: Smoking; tobacco control; youth and second-hand smoking; hospitality industry

March 2010

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1 Introduction

Tobacco is the single most preventable cause of death in the world (WHO, 2008). To curtail its use, many countries have tightened their tobacco control policies. In recent years, two measures have received particular attention, public smoking bans and youth access laws (see WHO, 2007). These measures aim at reducing exposure to secondhand smoking and smoking prevalence in minors. Public smoking bans, however, remain highly controversial because of their innate risk of adversely affecting businesses, particularly in the hospitality industry. Likewise, little is known on the effectiveness of youth access laws in curbing the ability of minors to purchase cigarettes.

The effectiveness of youth access laws is of great interest for public health policy. Tobacco is highly addictive and smoking initiation overwhelmingly occurs in teenagehood. Youth access laws, if effective in cutting smoking initiation rates among minors, have the potential to significantly reduce future prevalence of tobacco dependence and tobacco related diseases among adults (Gruber and Zinman, 2000; Gruber, 2001b; Case, Fertig and Paxson, 2005).[1] Furthermore, curtailing minors' access to tobacco may potentially be a more effective instrument to reduce smoking initation among youths than tax-driven price policies, as young teenagers do not appear to be very price-sensitive (Gruber, 2001b; DeCicca, Kenkel, and Mathios, 2002). The costs of smoking bans to businesses in the hospitality industry, in turn, are crucial for the political and public support that can be amassed for this tobacco control measure. Furthermore, they are indispensable for an objective assessment of the net economic effects of this instrument.

Empirical evidence on the effectiveness of youth access laws is still mixed (e.g. Chaloupka and Warner, 2000; Chaloupka and Grossman, 1996; Gruber (2001a); Gruber and Zinman, 2000; Rigotti et al., 1997). Lack of enforcement and insufficient retailer compliance, it appears, are often to blame that policy initiatives, such as smoking age rises, the banning of point-of-sale advertising, or the equipment of vending machines with remote control lockout devices that render machines inoperable until activated by the management, do not achieve their stated objective (Ling, Landman, and Glantz, 2002; DiFranza, Savageau, and Aisquith, 1996). Indeed, the 2007 European Tobacco Control Report explicitly criticises lack of retailer compliance as a main obstacle to the effectiveness of youth access laws in EU member countries (WHO, 2007). As a distribution outlet of cigarettes, vending machines are particularly controversial, as they tend to be heavily used by minors, being self-service and mostly under control of neither retailers nor adults.[2] Although ar-

[1] Recent evidence also suggests that the younger individuals are when they first try smoking, the higher is their risk of becoming regular smokers and the lower is their likelihood of quitting (van Ours, 2006).

[2] According to the German Center for Cancer Research (DKFZ, 2008), minors aged 14-15 in Germany used vending machines more than any other distribution outlet in the period 2004 to 2006 (52.8% usage rate).

guably the most accessible outlet of tobacco for youths, vending machines have been investigated in but a handful of studies (see Czart et al. (2001), Rigotti et al. (1997), Chaloupka and Grossman (1996), and Forster et al. (1992)). Furthermore, these studies produced only mixed evidence on the effectiveness of restrictions imposed on the use or placement of vending machines in curbing the availability of cigarettes to youths.

Smoking bans and their effects on businesses in the hospitality industry have been studied extensively.[3] Most studies in this literature find no evidence that smoking bans harm entrepreneurs. However, the great bulk of the existing literature focuses on but one country, the United States, where smoking prevalence is considerably lower than in other industrialized countries, such as the European Union (WHO, 2008). As any potential harm to businesses in the hospitality industry is likely to increase in magnitude with the overall share of smokers in the population, the US evidence may not be very informative on the consequences of smoking bans in such countries. Indeed, three recent studies for Europe, Adda, Berlinski and Machin (2007) for Scotland and Ahlfeldt and Maenning (2009) and Kvasnicka and Tauchmann (2010) for Germany, do find evidence that public smoking bans in these countries harmed businesses in the hospitality industry. Furthermore, and more generally, none of the existing studies (US and non-US) has investigated the very customer behavior of smokers, that is the prime (treatment) group potentially affected by smoking bans.[4] This is a clear shortcoming in the literature, one that can be attributed to the lack of objective (non-survey) data on the behavior of smoking customers. Information on changes in the out-going and customer behavior of smokers is useful for three main reasons. First, it can add to a better understanding of the causal pathways that underlie the effects of smoking bans in the hospitality industry. Second, it can provide an upper bound for the magnitude of any economic harm that is caused to businesses. And third, it can help to better control for unobservable trends that may otherwise confound the relationship between smoking bans and industry sales.

Using a unique dataset of monthly state-level revenues of a leading cigarette vending machines operator in Germany for the period January 2006 to August 2008, we investigate the short-run effects of two different youth access laws and two types of smoking bans on cigarette sales in Germany: (i) the requirement to equip vending machines in Germany with devices for electronic age verification (EAV); (ii) the increase in the federal legal minimum smoking age from 16 to 18; (iii) the country-wide smoking ban in federal buildings; and (iv) the gradual introduction of state-level public smoking bans in the hospitality industry. Unlike survey-based information on

[3] See Scollo and Lal (2008) for the most comprehensive literature review to date and Fleck and Hanssen (2008) for a critical discussion of empirical strategies employed in the literature.

[4] Existing studies have used a variety of performance measures, such as taxable sales (by far the most common), employment levels, number of bankruptcies, or proprietor predictions.

cigarette purchases that is potentially subject to misreporting, sales at cigarette vending machines are an objective outcome measure. Furthermore, data on cigarette sales at vending machines are indispensable for investigating the effectiveness of the first reform (i). They are also of particular interest concerning the effects of the smoking age rise (ii), as vending machines are the most easily accessible outlet of cigarettes for minors, and of valuable use for gauging the influence of public smoking bans in the hospitality industry on business sales and the customer behavior of smokers (iv). In addition, and more generally, sales at vending machines in different locations aid the identifcation of the effects of these various reforms (see below). With the highest number of cigarette vending machines per capita in the world, about half of which are located outdoors, Germany furthermore represents a most interesting setting for analysing cigarette vending machine sales data.[5]

We find a strong negative effect of EAV devices on cigarette sales, particularly at vending machines that are located outdoors or in premises which are strongly frequented by youths (such as youth hostels, youth centers, and discotheques for younger age cohorts). In contrast, there is no evidence for an adverse effect on indoor sales of the country-wide smoking ban in federal buidlings, and no evidence for an effect on sales of the increase in the legal minimum age for consuming and purchasing tobacco, an increase from which vending machines, unlike other retail outlets, remained exempted until January 2009. Finally, state-level smoking bans appear to have reduced cigarette sales at indoor vending machines, especially in bars and in establishments that are strongly frequented by youths, such as discotheques.

Our analysis contributes in several ways to the existing international literature on smoking and the law. Foremost, this study is the first to use comprehensive vending machines sales data. Such data allow us to study not only the effects of a novel and most stringent youth access policy initiative, the requirement to equip cigarette vending machines with electronic devices for age verification. It is also most useful for studying the effectiveness of other youth access laws and for investigating the likely costs of public smoking bans to the hospitality industry.

Tobacco control measures are in the majority targeted either at a specific age group (minors in the case of smoking age rises) that can be expected to frequent certain localities - and hence vending machines - more often than others (e.g. youth hostels, youth centers, or discotheques), a specific distribution outlet (vending machines in the case of locking devices), or a specific location in which smoking is no longer permitted (indoors in the case of public smoking bans). Data on cigarette sales at vending machines in suitably selected localities (e.g. indoors, outdoors, in bars, or in estab-

[5] About 726,000 vending machines were operative in Germany in 2004, that is one machine for every 113th citizen (Hanewinkel and Isensee, 2006).

lishments frequented mostly by youths) provide important information that helps to identify the effects of these various tobacco control measures. And such data provide first (objective) evidence on the customer behavior of smokers, evidence that to date is lacking entirely in the literature on the effects of public smoking bans on businesses in the hospitality industry.

Vending machine sales data also help to control for potential unobservable state-level trends in smoking prevalence, as relative (rather than absolute) state-level sales at vending machines in different locations can be investigated (e.g. indoor sales relative to outdoor sales). State-specific trends in smoking prevalence, induced, for example, by state demographics, state anti-smoking campaigns, or differences in state GDP growth or state unemployment, may potentially affect *overall* cigarette sales in a state, but should not affect or not strongly affect *relative* sales at vending machines in different locations. The use of vending machine sales data furthermore significantly aids the identification of the effects of country-wide reforms, such as the smoking age rise and the introduction of EAV devices in Germany. For again, such reforms should affect sales at vending machines in different locations to different degrees.

Finally, our analysis of public smoking bans is one of the few non-US studies to explore the costs of public smoking bans to businesses. Furthermore, and in contrast to most other countries, public smoking bans in Germany were introduced gradually at state level. We can hence exploit variation in smoke-free policies not only across time but also across regions to identify the effects of public smoking bans on the hospitality industry.

The paper is structured as follows. Section 2 provides basic statistics for Germany on the use of tobacco and documents the four tobacco control measures adopted at federal, respectively state level. Section 3 describes the data, Section 4 presents and discusses the empirical results, and Section 5 concludes.

2 Tobacco Use and Tobacco Control in Germany

2.1 Tobacco Use

Smoking prevalence in Germany is high, both among adults and youths. According to the latest report of the Federal Ministry of Health on addiction and drugs, every third adult and every sixth adolescent aged 12 to 17 in Germany smokes regularly (BMG, 2008). According to the same report, an estimated 140,000 persons per annum die prematurely because of active smoking and overall costs of smoking to the German economy total nearly 19 billion Euros per year.[6]

[6] Another 3,000 persons are reported to die from exposure to second-hand smoke.

Adult smoking prevalence has declined over the last ten years, albeit on a small scale.[7] Youth smoking prevalence, in contrast, has fallen dramatically, particularly in the more recent past. According to the Federal Centre for Health Education (BZgA, 2008), smoking prevalence among youths aged 12 to 17 has nearly halved between 2001 and 2008. In 2001, 27.2% of boys and 27.9% of girls in this age bracket smoked regularly. By 2008, these figures had fallen to 14.7%, respectively 16.2%. Morover, rates of decline appear to have increased lately, particularly for boys: from 2005 to 2008, smoking prevalence among male adolescents fell by approximately one third (and among female youths by one seventh).

Industry sales statistics since 2006, however, point to only a modest decline in aggregate cigarette consumption. According to the Federal Statistical Office, 88 billion cigarettes were sold in Germany in 2008, 3.8% less than in 2007. Worth 19.4 billion Euros (-2.8%), these sales generated 12.3 billion Euros of tax income for the government (-3.8%), making the tobacco tax the second-largest revenue-yielding excise tax in Germany (the largest being the petroleum tax). Year-to-year changes in these statistics were even somewhat smaller from 2006 to 2007 (-2.1%, 0.4%, and -1.2% respectively).[8]

Cigarette vending machines have been traditionally an important tobacco outlet in Germany. Furthermore, at least until recently, they have also been heavily used by adolescents (BMG, 2008). According to industry sources, 550,000 vending machines were operated in Germany in 2006, accounting for 22% of all cigarettes sold (BTWE, 2007). In 2007, however, the number of vending machines fell dramatically to 460,000 (-16.4%), and their share in total cigarette sales plummeted to a low 13% (BTWE, 2008). In other words, a major reallocation occured in purchasing patterns between 2006 and 2007, away from vending machines to other distribution outlets for cigarettes, yet with little, if any effect on total cigarette sales as documented above.

2.2 Tobacco Control

Tobacco control measures in Germany both increased in number and strictness over the last years (for a recent overview, see Göhlmann and Schmidt, 2008). Tobacco taxes have been raised several times since 1999 (the last hike occured in September 2005), particularly in 2003 and 2004.[9] Since 2007, however, the emphasis of tobacco control measures in Germany began to shift markedly in kind and focus, now targeting directly youth smoking and exposure to second-hand smoking. Four

[7] According to the 2007 European Tobacco Control Report of the WHO Regional Office for Europe, Gemany ranks sixth among countries in western Europe in male daily smoking prevalence (after Austria, Portugal, Luxembourg, Andorra, and Spain) and tenth in female daily smoking prevalence (WHO, 2007).

[8] Major declines in the number of cigarettes sold, in sales revenue, and in tax income generated, however, occured from 2002 to 2003, and from 2003 to 2004. Both 2003 and 2004 saw major tobacco tax increases.

[9] According to the 2007 European Tobacco Control Report, Germany now has one of the highest taxes on tobacco products in Europe (currently about 76%) and ranks fourth in the European Union in its retail sale price of the most popular price cigarettes (WHO, 2007).

major initiatives were taken - two for each target (see Figure 1): (i) the requirement from January 2007 to equip vending machines in Germany with devices for electronic age verification (EAV); (ii) the increase in the federal legal minimum smoking age from 16 to 18 in September 2007; (iii) the country-wide smoking ban in federal buildings, also effective from September 2007; and (iv) the introduction of state-level public smoking bans, which were enacted between August 2007 and July 2008.

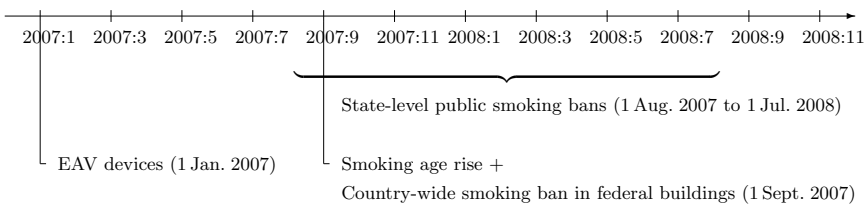

FIG. 1: Timeline of tobacco control initiatives in Germany between January 2007 and July 2008.

Electronic Age Verification: Intended to curb youth access to cigarettes, the first measure (EAV) surpasses in scope and strictness most existing locking device regulations in other countries.[10] It requires smokers to verify electronically their age at vending machines before they can purchase cigarettes. To do this, customers may use either a bank card with a money chip on it that contains information on the cardholder's age or a (machine readable) European driving license which provides age information on its holder. Indoors, and particularly in bars and restaurants, however, customers not in possession of either a bank card with a money chip or a European driving licence could still ask staff for a so-called 'ziggi card', to be returned upon purchase, to verify their age at vending machines located in the premise. These cards are business-/machine-specific, that is they are valid only in the respective business and nowhere else. Although targeted explicitly at youths, the introduction of EAV devices certainly made purchases at vending machines also more inconvenient for adults. What is more, for many it may have made them impossible, at least outdoors, as not every adult at the time possessed the required electronically readable documents: money chips were little used before 2007 for making purchases, and far from all bank cards were equipped with them; similarly, many adults at the time possessed only the German paper driving licence (and many probably still do), the predecessor to the new European driving license which comes in credit-card format.

[10] Elsewhere remote control lockout devices are used that render machines inoperable until activated by the management. Apart from Germany, EAV devices that do not require management involvement are at present used only in neighboring Austria. But they are currently being considered for adoption also in other countries, most notably in Japan which like Germany has a very high vending machine density.

Smoking Age Rise: The second measure, that is the September 2007 increase in the legal minimum age, made the purchase of tobacco illegal for individuals aged less than 18 (previously 16). Cigarette vending machines, however, were explicitly exempted from this measure until January 2009 to grant operators sufficient time for making the necessary adjustments to their EAV systems. If in possession of the required electronically readable documents for age verification, youths aged 16 and 17 could hence continue to purchase cigarettes at vending machines throughout the period September 2007 to December 2008. In fact, they may well have increased their use of this tobacco outlet, as alternative distribution channels (news agents, supermarkets, gas stations) now were no longer available to them.

Federal Smoking Ban in Federal Buildings: The September 2007 country-wide smoking ban prohibits smoking in all federal public buildings, in all public means of transport, and in railroad stations unless in specially designated smoking areas. Federal public buildings include administrative buildings, government agencies, courts, as well other federal authorities, institutions, and foundations.

State Smoking Bans: The decision to ban smoking in public places was taken in early 2007 by unanimous vote at a conference attended by health ministers from each of Germany's sixteen federal states. It was left to states, however, to devise and enact such bans. In accordance with the agreement, all of Germany's states introduced smoking bans. However, they did so at different points in time between August 2007 and July 2008 (see Table 1 below). Baden-Wurttemberg and Lower Saxony were the first (both in August 2007). They were joined in October 2007 by Hesse, and in January 2008 by eight further states (Bavaria, Berlin, Brandenburg, Bremen, Hamburg, Mecklenburg-Western Pomerania, Saxony-Anhalt, and Schleswig-Holstein). Rhineland-Palatinate, Saarland, and Saxony followed in mid February 2008, and North-Rhine Westphalia and Thuringia in July 2008. As shown in Table 1, state-level smoking bans varied not only in their date of enactment, but also in the pre-announced date from which any violations would be fined by state authorities, and to some degree also in their scope and strictness (allowance of separate smoking rooms). As shown in column (2), of the eight states that imposed a smoking ban from January 1, 2008, four began to fine violations only from July 1 2008, and one from as late as August 1 2008 (Mecklenburg-Western Pomerania). And of the three states that banned smoking in public places in February, one (Saarland) started to fine violations only from June 2008. Furthermore, with the exception of Bavaria, state smoking ban regulations allowed bars and restaurants to operate separate smoking rooms (see column 3). And in ten of the sixteen German states, state bans also permitted dance clubs to operate such smoking rooms (column 4). By definition, single-room

businesses could not install a separate smoking room.[11] This differential treamtment of small and large establishments in state smoking ban regulations sparked major criticism. Following a constitutional complaint of several owners of discotheques and bars, the Federal Constitional Court ruled on July 30 2008 that smoking in single-room businesses was to be allowed until December 31 2009, a deadline by which states had to revise their legislation.[12]

Table 1: State smoking bans: introduction, fining of violations, and exemptions

Federal state:	State smoking bans: Introduction	Fining of violations	Exemptions: Smoking rooms permissible in: bars/restaurants	clubs
	(1)	(2)	(3)	(4)
Baden-Wurttemberg	2007/08/01	at once	*yes*	*yes*
Bavaria	2008/01/01	at once	*no*	*no*
Berlin	2008/01/01	2008/07/01	*yes*	*yes*
Brandenburg	2008/01/01	2008/07/01	*yes*	*no*
Bremen	2008/01/01	2008/07/01	*yes*	*yes*
Hamburg	2008/01/01	at once	*yes*	*yes*
Hesse	2007/10/01	at once	*yes*	*yes*
Lower Saxony	2007/08/01	2007/11/01	*yes*	*no*
Mecklenburg - West Pomerania	2008/01/01	2008/08/01	*yes*	*no*
North Rhine - Westphalia	2008/07/01	at once	*yes*	*yes*
Rhineland - Palatinate	2008/02/15	at once	*yes*	*yes*
Saarland	2008/02/15	2008/06/01	*yes*	*yes*
Saxony	2008/02/01	at once	*yes*	*no*
Saxony - Anhalt	2008/01/01	2008/07/01	*yes*	*no*
Schleswig - Holstein	2008/01/01	at once	*yes*	*yes*
Thuringia	2008/07/01	at once	*yes*	*yes*

Note: Information on individual states was compiled from original law texts and from a survey of state-level smoking ban legislation by the German Hotels and Restaurants Federation (DEHOGA, 2008).

3 Data

The empirical analysis is based on a unique state-level dataset of monthly sales at vending machines and numbers of vending machines operated by a leading provider of such machines in Germany. Covering the period January 2006 to August 2008, the dataset contains information on the entire vending machine stock (more than 130,000 vending machines) of the provider, who is active in fifteen of the sixteen German federal states.[13] Monthly statistics for states provided in the data

[11] Given the lack of official data on establishment size, however, the extent to which businesses in the hospitality industry were able to make use of these exemptions is not known.

[12] However, the court made this allowance only for single-room businesses that have less than 75 square meters of guest space, that do not serve self-prepared food, that deny access to youths, and that clearly designate their business as a locality in which smoking is permitted.

[13] The provider does not operate any vending machines in the state of Saarland. With only about one million residents, Saarland is the second least populated state in Germany.

include total revenue made and machines operated, as well as disaggregate revenue and machine figures by indoor/outdoor location and by type of indoor locality of vending machines, such as bars or establishments that are particularly frequented by youths (EFY), including youth hostels, youth centers, discotheques for younger age cohorts, localities near schools or youth centers, and other youth establishments. Summary statistics of our data set are provided in Tables 2 and 3.

As shown in Table 2, indoor vending machines account for about half of the total machine stock and also for half of the total sales revenue of the provider. About one seventh of total revenue is made at vending machines located in bars (a quarter of total indoor sales), and somewhat less than three percent in EFY. Monthly averages of vending machines dropped sharply from about 130,000 in 2006 to 107,000 in 2007 (-18%), followed by a further yet far more moderate dip (-2%) in the first eight months of 2008. Concomitant to this decline in vending machines, sales also dropped. Average monthly sales slipped 38% from 2006 to 2007, and another 8% in the period January to August 2008 relative to 2007 (not tabulated). The share of indoor vending machines also declined, albeit only on a very small scale. Their share in total revenues generated, however, rose by 8 percentage points from 2006 to 2007. The respective revenue shares of bars and EFY also rose from 2006 to 2007 and fell, like the share of total indoor revenue, from 2007 to 2008.

Table 2: Vending machines and sales in Germany by location

	Machines:		Sales:		
	total (nos.)	indoor (%)	indoor (%)	bars (%)	EFY (%)
2006[1]	129,600	50.0	49.5	13.0	2.6
2007[1]	106,970	47.8	57.4	15.5	2.9
2008[2]	105,020	47.3	55.3	14.6	2.4

Note: [1] Monthly averages in respective calendar year. [2] Monthly averages for period January to August 2008. *EFY* = establishments particularly frequented by youths, including youth hostels, youth centers, discotheques for younger age cohorts, localities near schools or youth centers, and other youth establishments.

The regional distribution of vending machines shows great dispersion, as do state-level shares of revenues generated indoors, in bars, and in EFY (see Table 3). The greatest numbers of vending machines are operated in North Rhine-Westphalia, Baden-Wurttemberg, and Lower Saxony, and the fewest in Bremen and Thuringia. In part, absolute figures correspond to respective state population sizes. But vending machine numbers also reflect past expansions of the provider, particularly through acquisitions of regional competitors, which cause deviations from this pattern. The clearest examples are Saarland, where no machines are operated, and Thuringia, where only a few machines are located. The highest indoor revenue shares are found in the city states of

Berlin, Bremen, and Hamburg. Berlin and Bremen also have the highest revenue shares of bars and one of the largest revenue shares of vending machines in EFY. The latter is exceptionally high in Thuringia. However, as already noted, only few vending machines are operated in this state by the provider.

Table 3: Vending machines and sales in individual states by location

	Machines: total (nos.)	Sales: indoor (%)	bars (%)	EFY (%)
Baden-Wurttemberg	22,285	41.0	11.1	1.8
Bavaria	3,287	48.5	9.6	1.3
Berlin	5,058	83.6	23.5	5.9
Brandenburg	3,905	56.1	17.4	2.8
Bremen	455	66.5	21.6	5.0
Hamburg	5,314	69.6	15.5	2.2
Hesse	4,764	55.4	9.7	2.4
Lower Saxony	12,169	46.1	12.0	2.2
Mecklenburg-West Pomerania	3,903	54.2	17.0	4.6
North Rhine-Westphalia	28,722	61.9	18.1	3.0
Rhineland-Palatinate	3,891	36.0	11.0	1.3
Saarland	–	–	–	–
Saxony	2,249	60.1	11.4	5.8
Saxony-Anhalt	3,111	56.9	16.1	3.1
Schleswig-Holstein	8,653	49.0	12.3	2.2
Thuringia	59	56.4	13.5	14.1

Note: Monthly averages for period January 2006 to August 2008. '–' no data.

4 Results

4.1 Descriptive Analysis

Figure 2 documents for the period January 2006 to August 2008, how the provider's revenue from cigarette sales at vending machines in different locations (indoors, outdoors, bars, EFY) evolved over time (sales figures are normalized to one hundred in January 2006). As is evident, country-wide revenues from vending machines in the four locations all dropped sharply from December 2006 to January/February 2007, that is with the introduction of electronic devices for age verification. Vending machines that are located outdoors or in EFY experienced a particularly large drop in sales. Compared to December 2006, the former fell by roughly half, the latter by around a third. The fact that revenue generated declined more outdoors than indoors does not come at a surprise. As noted, in bars and restaurants, adult customers that did not have the required documents for electronic age verification could still ask staff for a vending machine specific 'ziggi card', an option not available at machines outdoors. Revenues, in contrast, show little if any change following the

September 2007 rise in the legal smoking age and introduction of a smoking ban in federal buildings. They only dip temporarily in September 2007 (month 21 in Figure 2). Finally, the period from August 2007 to July 2008, which saw the gradual enactment of state smoking bans, exhibits a trend decline in indoor sales, particularly in EFY.

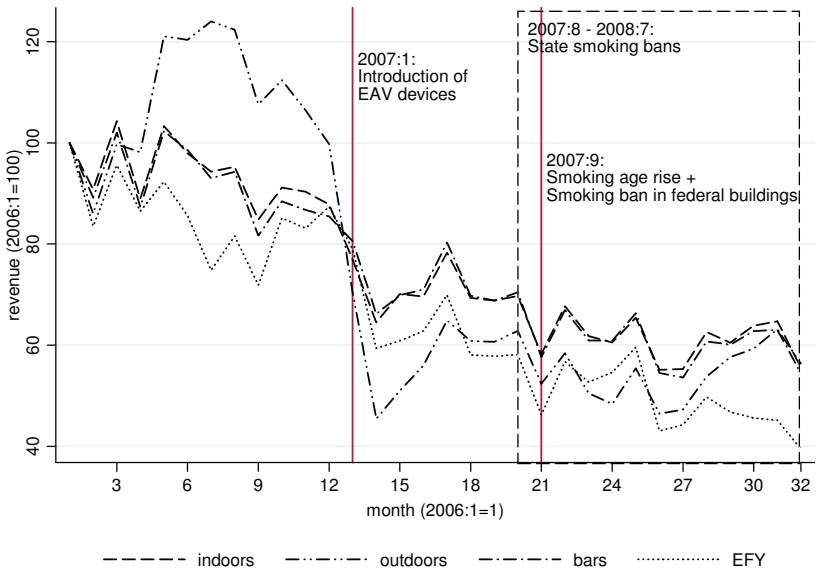

FIG. 2: Country-wide monthly revenues from vending machines in different locations, 2006:1 to 2008:8.

Figure 3 shows how state revenues per machine indoors, outdoors, and in bars developed on average across states shortly before and after the introduction of a smoking ban. As smoking bans were introduced in states in different months, the graph uses a relative time scale where month zero marks the respective month of enactment. As is evident, average monthly revenue per machine drops in the first month after a smoking ban is introduced, recovers somewhat thereafter but fails to return in full to its pre-ban level. This pattern is observable for both indoor and outdor vending machines. However, the decline at indoor vending machines is more pronounced than at outdoor vending machines, and it is even somewhat larger at indoor machines located in bars. These patterns in cigarette sales in the vicinity of the enactment of state smoking bans suggests that smoking prevalence in bars and indoor localities more generally was affected by the introduction of public smoking bans.

While these plots are suggestive of an adverse effect of smoking bans on sales, and even more so

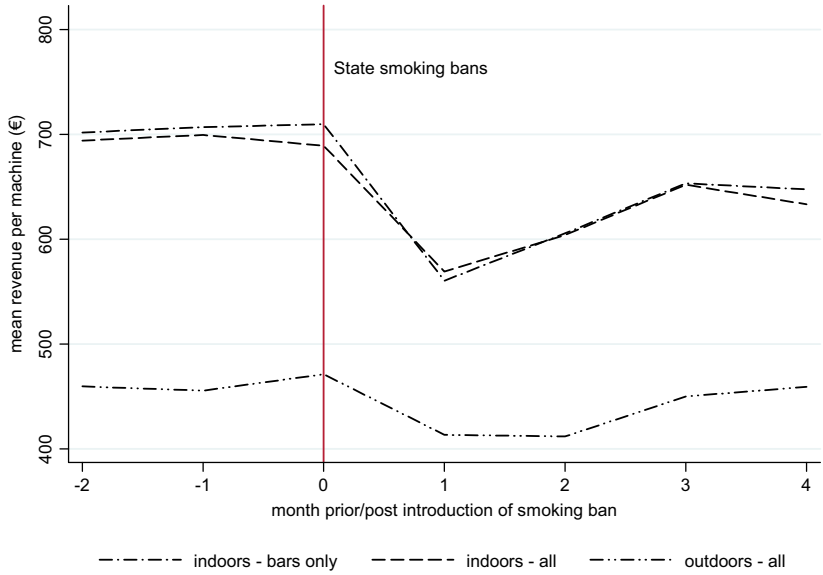

FIG. 3: Average monthly revenues per vending machine in different locations in the vicinity of state smoking bans, relative time scale.

of EAVs, regression analysis is required to establish causality. In particular, country-wide and/or state-specific trends in smoking prevalence and tobacco sales by outlet type might confound the relationship between the individual policy measures considered and cigarette sales at vending machines. In the next setion, we address this question by exploiting for identification variation in policies across time and state, as well as information on vending machine sales in different localities that are disproportionately affected by these tobacco control measures.

4.2 Regression Analysis

4.2.1 Empirical Strategy

To gauge the respective effects on sales of the different pieces of anti-smoking legislation, we run OLS regressions of the following type:

$$y_{it} = \beta_0 + \beta_1 EAV_t + \beta_2 SmokingBan_t^{Fed} + \beta_3 SmokingBan_{it}^{State} + \alpha_i + \gamma_t + \epsilon_{it}, \quad (1)$$

where y_{it} is a measure of sales revenue in state i in month t. Different types of sales revenues will be considered in the analysis, including both absolute and relative sales at vending machines in different locations. EAV_t is an indicator variable that takes the value one from January 2007 onwards, that is the month from which cigarette machines throughout Germany had to be equipped

with EAV devices, and zero otherwise. Likewise, dummy variable $SmokingBan_t^{Fed}$ takes value one for observations in or after September 2007, the month in which the legal age for smoking and purchasing tobacco products was raised to 18 years and smoking was banned from federal buildings in Germany. $SmokingBan_{it}^{State}$, in turn, is a dummy variable that takes the value one if a state-level smoking ban is in force in state i at time t, and zero otherwise. Finally, fixed state effects (α_i) and month effects (γ_t) are included to control for respectively time-invariant factors at state level that may affect regional sales and potential time trends in vending machine sales common to all states. State fixed effects account, among others, for average level differences in smoking prevalence and demographics between states, and for average differences in sales volume that are attributable to the differing sizes of vending machine stocks operated by the provider in individual states. Monthly indicators, in turn, capture common components in state-level changes in sales over time that may be caused, for example, by nation-wide anti-smoking campaigns, common smoking trends, average changes in income, or increases in VAT taxes (in January 2007). In all regressions, standard errors are corrected for heteroscedasticity.

4.2.2 Main Results

Absolute Sales: In a first set of regressions, we use five different monthly absolute revenue statistics for a state as dependent variables: total revenue, revenue at outdoor vending machines, revenue at indoor vending machines, revenue at indoor vending machines located in bars, and revenue at indoor vending machines located in premises particularly frequented by youths (such as youth hostels, youth centers, and discotheques for younger age cohorts). Considering sales in these different locations helps to identify the effects of the four tobacco control policies enacted in the observation period, particularly those enacted country-wide. Table 4 contains the main regression output.

With respect to total monthly revenue realized in a state, column 1 of Table 4 shows that all four policy reforms led to a reduction in sales. In line with the descriptive time-series plots in Figure 2, the January 2007 requirement to equip vending machines throughout Germany with EAV devices has the largest adverse effect on revenues. Across states, it led to an average reduction in sales of about 23% (=100*(exp(-0.26)-1)). Second in magnitude is the effect of state-level smoking bans on total monthly revenues (-9%), followed by the joint effect of the simultaneous rise in the legal smoking age and the country-wide ban of smoking in federal buildings both of which took force in September 2007 (-7%).

As shown in column 2, and consistent with expectations, EAV devices had an even stronger adverse

TABLE 4: EFFECTS ON STATE-LEVEL MONTHLY REVENUES FROM SALES OF CIGARETTES AT VENDING MACHINES: ABSOLUTE SALES FIGURES IN DIFFERENT LOCATIONS, 2006:1 – 2008:8

Dep. variable (in logs):	Monthly revenue generated:				
	Total	Outdoors	Indoors	Bars	EFY
EAV	-0.26^{***}	-0.39^{***}	-0.18^{***}	-0.16^{***}	-0.44^{***}
	(0.03)	(0.04)	(0.03)	(0.03)	(0.05)
$SmokingBan^{Fed}$	-0.07^{**}	-0.04	-0.11^{***}	-0.08^{**}	-0.13^{**}
	(0.03)	(0.04)	(0.03)	(0.04)	(0.06)
$SmokingBan^{State}$	-0.09^{***}	-0.04^{*}	-0.11^{***}	-0.16^{***}	-0.24^{***}
	(0.01)	(0.02)	(0.02)	(0.02)	(0.04)
State fixed effects †	*yes*	*yes*	*yes*	*yes*	*yes*
Month fixed effects †	*yes*	*yes*	*yes*	*yes*	*yes*
N	480	480	480	480	480

NOTE: Results from OLS regressions. Standard errors (reported in parentheses) are corrected for heteroscedasticity. *,**,*** denote statistical significance at the 10%, 5%, and 1% level. † set of indicators is jointly significant at the 1% level in all regressions. Definitions and abbreviations: EAV = electronic age verification requirement, from January 2007; $SmokingBan^{Fed}$ = smoking age rise and smoking ban in federal buildings, from September 2007; $SmokingBan^{State}$ = state-level smoking ban enacted between August 2007 and July 2008.

effect on revenues from sales at outdoor vending machines (-32%). $SmokingBan_t^{Fed}$, in contrast, exerts no statistically significant effect on outdoor sales. And state-level smoking bans reduce the same by a magnitude that is less than half the size of their effect on total state revenues (-4%).

Sales at indoor vending machines (see column 3), in turn, show less of a slide following the introduction of EAV devices (-16%), but were harder hit than total sales by both the smoking age rise and the simultaneous smoking ban in federal buidlings as well as the state-level smoking bans. Each of these reduced indoor sales by about 10%.

A similar change in the estimated coefficients is observable when considering monthly sales at vending machines in bars only (column 4). However, and as may be expected, sales in bars are less affected by the introduction of EAV devices and by the federal smoking age rise and the nationwide smoking ban in public buildings, that is the September 2007 reforms, and more strongly reduced by the state level public smoking bans than overall indoor sales at vending machines. The magnitude of the estimated effect in bars (-15%), however, is rather moderate, which suggests that any adverse consequences for revenues and profits of these businesses are likely to have been rather limited. This reading of this result is consistent with the findings of Ahlfeldt and Maenning (2009) and Kvasnicka and Tauchmann (2010) who studied sales data of the hospitality industry in Germany.

Finally, and also consistent with expectations, EAV devices reduce sales in EFY more than any of the other four sales categories considered (column 5). It is also here that state smoking bans

exert their greatest impact. This may be due to the fact that only nine of the fifteen states in our sample allowed for separate smoking rooms to be operated in dance clubs (an EFY locality) after the respective state smoking ban took force, but fourteen states allowed for such separate smoking rooms in bars. Also, the estimated negative coefficient of $SmokingBan_t^{Fed}$ is largest for EFY localities. This is little surprising, as it is in EFY locations that the smoking age rise can be expected to reduce sales at vending machines most.

We also ran additional regressions (not reported) to assess more directly the impact of the September 2007 federal smoking ban in federal buildings.[14] Using different sales measures to proxy sales at federal buildings (there is no marker in the data to distinguish between vending machines located in federal and state buildings), we do not find any evidence that the federal smoking ban affected sales.[15]

Relative Sales: So far, and apart from our policy variables, we controlled only for state fixed effects and common time trends in our regression analysis. However, states may also have witnessed state-specific time trends in cigarette consumption, respectively in overall sales of cigarettes at vending machines. Such state trends may be driven by state anti-tobacco campaigns, state-level changes in preferences, differential income growth across states, and state-specific demographic changes. Given our short observation period, such underlying (and potentially unobservable) state trends are rather unlikely to severely bias our results. Nevertheless, to control for such potentially confounding state-level trends, we use in a second set of regressions relative measures of sales for our dependent variable y_{it}, such as revenue at indoor vending machines relative to revenue at outdoor vending machines in a particular state and month (see Table 5). The use of relative sales measures in different locations provides a powerful means to control for unobserved state-specific trends that may affect overall state purchases of cigarettes at vending machines or state cigarette consumption more generally. In addition, as noted in Section 1, each of the policy measures should affect sales at vending machines in certain locations more than it should affect sales in others. For each tobacco control measure considered is targeted either at a specific group (minors in the case of EAVs and the smoking age rise) or at specific locations in which smoking is no longer permitted (indoors in the case of state smoking bans; in federal buildings for the federal smoking ban).

As Table 5 shows, EAVs caused total indoor sales and indoor sales in bars to increase markedly relative to outdoor sales (see top row entries of columns 1 and 2, respectively), but appear not to

[14] Results are available from the author upon request.

[15] We used three outcome measures: sales at: (i) military barracks, public authorities, airports; (ii) military barracks, public authorities, airports, stops for short- and long-distance public transport; and (iii) military barracks, universities, other educational institutions, public authorities, hospitals and homes for the elderly, airports, railroad stations, and stops for short- and long-distance public transport.

TABLE 5: EFFECTS ON STATE-LEVEL MONTHLY REVENUES FROM SALES OF CIGARETTES AT VENDING MACHINES: RELATIVE SALES FIGURES IN DIFFERENT LOCATIONS, 2006:1 − 2008:8

Dep. variable (in logs):	Monthly revenue generated:		
	indoors/outdoors	bars/outdoors	EFY/outdoors
EAV	0.21^{***}	0.23^{***}	-0.05
	(0.03)	(0.02)	(0.05)
$SmokingBan^{Fed}$	-0.07^{**}	-0.04	-0.09
	(0.03)	(0.03)	(0.07)
$SmokingBan^{State}$	-0.07^{***}	-0.12^{***}	-0.20^{***}
	(0.02)	(0.02)	(0.05)
State fixed effects †	*yes*	*yes*	*yes*
Month fixed effects †	*yes*	*yes*	*yes*
N	480	480	480

NOTE: Results from OLS regressions. Standard errors (reported in parentheses) are corrected for heteroscedasticity. *,**,*** denote statistical significance at the 10%, 5%, and 1% level. † set of indicators is jointly significant at the 1% level in all regressions. See Table 4 for the definition of variables.

have affected sales in EFYs any different form sales at outdoor vending machines (top row entry of column 3). Both sales in EFYs and sales at outdoor vending machines therefore witnessed declines of similar magnitudes - which were dramatic as we know from Table 4.

The September 2007 rise in the legal smoking age from 16 to 18 and the simultaneous banning of smoking in federal buildings, in turn, reduced indoor sales somewhat relative to outdoor sales, but did not affect either sales in bars or sales in EFYs relative to outdoor sales, which stayed unchanged (see Table 4). The fact that sales at vending machines in EFY localities did not change statistically significant from outdoor sales following the September 2007 rise in the legal smoking age casts doubt on the effectiveness of this tobacco control measure in reducing cigarette purchases by youths.

Finally, the introduction of state-level smoking bans reduced all three relative sales measures, albeit to varying degrees. Relative sales in EFYs appear hardest hit, followed by relative sales in bars and relative total sales indoors. The larger drop in bars (and EFYs) than overall indoors suggests that (youth) smokers either frequented bars (EFYs) disproportionately less often than other indoor premises and/or reduced their quantity of cigarettes smoked in these premises (i.e. outside or in separated smoking rooms, if available) more than they did elsewhere indoors. The latter, in turn, may be due to a reduced average time that (youth) smokers spent in bars (EFYs), a lower amount smoked by smokers per unit of time such a premise was attended, or a combination of both.

4.2.3 Further Results and Robustness Checks

Delayed Enforcement of State Smoking Bans: In seven states, violations of state public smoking bans were fined not from their date of enactment, but only after a transitionary period. To see whether this "delayed fining" has any effect on enforcement, that is on compliance with the new law, and hence on our results, we replaced our enactment-based dummy variable for state-level smoking bans with an enforcement-based indicator. The results are document in Table 6. As is evident, results are qualitatively unchanged from those reported in Table 5. Estimated coefficients for the average effect of state smoking bans on relative total indoor sales and on relative indoor sales in EFY, however, are somewhat larger in magnitude, which suggests that initial compliance with the ban was not completely forthcoming in states that did not fine violations right from start. Note, however, that for relative sales in bars, the estimated coefficient does remain unchanged.

TABLE 6: EFFECTS ON STATE-LEVEL MONTHLY REVENUES FROM SALES OF CIGARETTES AT VENDING MACHINES: RELATIVE SALES FIGURES IN DIFFERENT LOCATIONS, 2006:1 − 2008:8

Dep. variable (in logs):	Monthly revenue generated:		
	indoors/outdoors	bars/outdoors	EFY/outdoors
EAV	0.21^{***}	0.23^{***}	-0.05
	(0.03)	(0.02)	(0.05)
$SmokingBan^{Fed}$	-0.05^{*}	-0.04	-0.01
	(0.03)	(0.03)	(0.06)
$SmokingBan^{State}_{Enforced}$	-0.10^{***}	-0.12^{***}	-0.28^{***}
	(0.02)	(0.02)	(0.04)
State fixed effects †	*yes*	*yes*	*yes*
Month fixed effects †	*yes*	*yes*	*yes*
N	480	480	480

NOTE: Results from OLS regressions. Standard errors (reported in parentheses) are corrected for heteroscedasticity. *,**,*** denote statistical significance at the 10%, 5%, and 1% level. † set of indicators is jointly significant at the 1% level in all regressions. See Table 4 for the definition of variables.

Placebo State Smoking Bans:[16] We also conducted a placebo reform experiment in that we pre-dated the individual months of enactment of state smoking bans by fifteen months. We then estimated the effects of these placebo reforms using data only from the actual pre-reform period (January 2006 to July 2007). In case any pre-reform placebo effects exist, one might suspect that timing of treatment (the introduction of smoking bans) across states is not truly exogenous conditional on the explanatory variables. No pre-reform placebo effects, in contrast, lend further support to the credibility of our the present estimates. Reassuringly, the estimated coefficient of the placebo smoking ban indicator is statistically insignificant and close to zero in magnitude for

[16]The regression output of this robustness check and the following checks can be obtained from the author upon request.

all three relative outcome measures.[17]

Sales in EFY Localities and Smoking Rooms in Dance Clubs: We next checked whether relative sales in EFY localities, which include dance clubs, are more affected by state smoking bans that do not permit separate smoking rooms in dance clubs (6 states).[18] To test this hypothesis, we add an indicator that takes the value one if our smoking ban variable turns one, but only for states that do not allow for such smoking rooms. If indeed of importance for relative indoor sales in EFY localities, the coefficient of this indicator should be negative and statistically significant. However, as it turns out, it is neither of the two.

Estimation Sample (sampling units and observation period): We also checked for the robustness of our results to changes in the sampling units and in the observation period that are considered in the analysis. Specifically, we exluded Thuringia from the estimation sample, as it is by far the smallest state in terms of revenue and number of vending machines operated by the provider. Again, the results are qualitatively unchanged. The effects of state public smoking bans on all three relative sales measures, however, are larger: -13% for relative overall indoor sales, -14% for relative indoor sales in bars, and -27% for relative indoor sales in EFY (compared to respectively -7%, -11%, and -18% in the baseline regressions). We next dropped observations from August 2008 from the analysis, as the ruling of the Federal Constitutional Court on July 30 2008 exempted some single-room businesses in the hospitality industry from the obligation to observe state smoking bans. Results, however, are largely unchanged, and in most cases virtually identical to those for the unrestricted estimation sample.

Additional Controls: We also added a control variable for monthly weather conditions in a state (average monthly rainfall). Weather conditions may influence the customer or outgoing behavior of smokers and hence their respective purchases of cigarettes at indoor and outdoor vending machines. Positive in sign (as expected) and statistically significant throughout, rainfall changes neither of our findings - qualitatively or quantitatively - on the effects of EAV devices, or of state public smoking bans on any of our relative sales measures. However, the magnitude of the estimated coefficient on $SmokingBan_t^{Fed}$ increases for relative overall indoor sales (to -0.12) and for relative indoor sales in bars (to -0.09), which now also is statistically significant (at 1% level), but remains

[17] As a placebo reform test should be run only with data from the pre-reform period (here months up to and including July 2007), we had to pre-date the individual state-level smoking bans by at least twelve months, so that the last state reforms of July 2008 fall in this period if pre-dated. Because eight states introduced state bans in January 2008, pre-dating their reforms by twelve months (or close to that figure, e.g. thirten months) would pick up part of the dramatic effect of the January 2007 introduction of EAV devices. We hence chose to pre-date sufficiently far to avoid this confounding influence. Results of our placebo reform experiment remain unchanged, if we pre-date state bans by sixteen or seventeen months.

[18] Sales at vending machines in dance claubs that are mostly frequented by youths account for an average of 68% of total sales in EFY across states in our sample (min=32%, max=98%).

small and insignificant for sales in establishments that are mostly frequented by youths (EFY). The evidence for an effect of the smoking age rise on youth purchases hence remains weak at best.

5 Conclusion

Tobacco control measures have proliferated in recent years. Most of these measures have been targeted either at second-hand smoking (public smoking bans) or at youth access to cigarettes. Public smoking bans remain controversial, however, as they risk to harm businesses, particularly in the hospitality industry. And youth access laws are still contested in their effectiveness of curbing the ability of minors to purchase cigarettes. Using a novel and unique data set on cigarette sales at vending machines in different localities, we investigated the effects of both types of measures by studying several recent tobacco control policies in Germany.

Our findings on EAV devices suggest that this measure was effective in curtailing minors' access to cigarettes at vending machines. However, the very large magnitude of the decline in overall sales that we find points also to very significant reductions in adult purchases. These were neither intended by the legislator, nor do they appear to have reduced overall cigarettes sales in Germany (not just at vending machines), as offical statistics show.

The lack of evidence for an effect of the smoking age rise, in turn, may seem surprising at first look. However, this rise came into effect only full eight months after EAV devices had been installed. It hence affected not all youths aged less than 18, but only those that were aged 16 or 17 and that *did* at the time already possess the necessary electronically readable documents to verify their age at vending machines (bank card with money chip or European driving license).

Finally, the country-wide smoking ban in federal buildings did not affect cigarette purchases in these premises. State smoking bans, however, reduced cigarette sales in bars, that is in those businesses of the hospitality industry that are likely to be harmed most in economic terms by smoking bans. The magnitude of the effect we find, however, suggests that any adverse consequences for revenues and profits of these businesses may have been rather limited. For this decline in cigarette sales represents but an upper bound of the losses in revenue incurred by businesses: after all, smokers constitute but a fraction of customers; and non-smokers might have frequented localities more often, for a longer time, or in greater numbers after a smoking ban, compensating, at least in part, for any losses incurred from smokers. First evidence on business sales in the hospitality industry in Germany is consistent with this interpretation.

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