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The Effect of a Sunday Liquor-Sales Ban Repeal on Crime: A Triple-Difference Analysis

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Background: This study investigates whether alcohol availability in state-run liquor stores affects crime nearby. In 2003, Pennsylvania repealed its Sunday alcohol-sales ban for a portion of its state-run liquor stores. We capitalize on this change in alcohol policy to assess the effect of alcohol availability on crime occurring within the vicinity of liquor stores that opened on Sundays in Philadelphia.

Methods: We employed a difference-in-difference-in-differences model that compared reported crime before versus after the change in alcohol policy, Sundays versus other days of the week, and the fraction of liquor stores affected versus not affected by the repeal. We used crime incident data in Philadelphia between 1998 and 2011.

Results: The repeal was associated with a significant increase in total and property-crime incidents occurring around Sunday-open state liquor stores in low-socioeconomic-status neighborhoods. We found no evidence of the displacement of crime to nearby areas.

Conclusions: This is the first triple-difference alcohol study that attempts to isolate the micro-spatial effects of a shift in alcohol availability on local crime patterns, and shows that the repeal of Sunday alcohol-sales restrictions may increase crime in poor urban areas.

Key Words: Alcohol Availability, Crime, Blue Law, Low-Socioeconomic-Status Neighborhood, Triple-Difference Analysis.

ALCOHOL AVAILABILITY MAY influence crime by increasing consumption and alcohol-induced impulsivity. Restrictions on alcohol availability may be an important crime control policy. Establishing a causal relationship between alcohol availability and crime, however, is difficult as individuals who misuse alcohol are also more likely to be risk takers who commit and are victims of crime (Carpenter and Dobkin, 2011). Identifying the extent to which specific restrictions or expansions of alcohol availability influences crime is important for informing policy. The current study aims to address this question by leveraging the 2003 repeal of "blue laws" in Philadelphia that permitted a fraction of state-run wine and spirits (W&S) stores to open on Sundays. We rely on a triple-difference design (difference-in-difference-in-differences or DDD) that compares crime in the pre- and postrepeal periods for W&S stores that are allowed to open on Sunday, compared to other days of the week, and compared to those that remain closed. This DDD design provides a more precise test of whether increased alcohol availability is causally linked to changes in crime nearby (Gruber, 1994).

We also use a novel geospatial approach to examine whether opening W&S stores on Sunday produces spillovers or displaces crime to adjacent areas. Unlike most previous studies that use large jurisdictions as the unit of analysis, this study attempts to identify dynamic changes in crime at a more granular level. Thus, this is the first DDD alcohol study that attempts to isolate the micro-spatial effects of a shift in alcohol availability on crime patterns. We also investigate whether the relationship between alcohol availability and crime differs by neighborhood socioeconomic (SES) status.

Blue Laws as Sunday Alcohol-Sales Ban

The United States has a long tradition of "blue laws" that prohibit commercial activities on Sundays to promote religious worship (Lovenheim and Steefel, 2011). Alcohol restrictions remain one of the few existing sets of blue laws. Since 1995, 17 states have repealed their blue laws on alcohol sales. Twelve states and the District of Columbia still prohibit any off-premise liquor sale on Sunday.[1] While repealing the Sunday sales prohibition is a method to raise tax revenues, public health and safety concerns are often cited as the basis for continuing these blue laws (Carpenter and Eisenberg, 2009; Heaton, 2012; Lovenheim and Steefel, 2011; McMillan and Lapham, 2006; Stehr, 2010).

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[1]Distilled Spirits Council of the United States. Sunday Alcohol Sales. Retrieved on April 5, 2015, from http://www.discus.org/policy/sunday/

The Pennsylvania Liquor Control Board (hereafter PLCB) regulates all alcohol-sale licensees in the state and operates a state monopoly of W&S liquor stores. In 2003, Pennsylvania relaxed its blue laws and amended its liquor code to allow 10% of its W&S stores to operate on Sundays. The liquor code was amended again in 2005 to allow 25%. This repeal affected only the *off-premise liquor* sales, not on-premise liquor sales in hotels and restaurants or brewed alcohol off-premise sales. Thus, the amendment of blue laws in Pennsylvania only impacted the effect of alcohol availability on crime around W&S stores. The amendment to Sunday W&S sales restrictions in Pennsylvania provides a unique setting to study the effects of off-premise alcohol sales on crime. On-premise beer and alcohol sales are strictly limited in Pennsylvania to no more than 1 per 3,000 in the local population. Off-premise beer sales in Pennsylvania are also restricted to designated places that only sell beer by the case.[2,3] This means that the change in law only affected alcohol availability on Sunday for off-premise W&S stores, and other aspects of alcohol distribution remained constant.

A particularly useful feature of this analysis is the fact that all off-premise W&S stores are operated by the state, such that profits and placement of stores are solely determined by the PLCB. Thus, the selection of which W&S stores were allowed to stay open on Sundays is uncorrelated with crime. If the PLCB deliberately considered crime in granting Sunday sales permits, levels or trends in crime prior to permit granting would predict permit selection. To check the potential for this form of selection bias, we estimated a logistic regression of Sunday-open permission grant (=1 if granted, =0 otherwise) on store-level time series variation and average crime prior to permit granting. Neither the variation in store-level crime variation over time (p-value = 0.501) nor average total crime (p-value = 0.496) was correlated with permit granting.[4]

Literature Review

Different alcohol restriction policies have been assessed for their association with crime, including excise taxes imposed on alcohol sales, minimum age alcohol access restrictions, and spatial/temporal restriction of alcohol availability. Carpenter and Dobkin (2011) note that the empirical evidence is the strongest for the relationship between crime and alcohol age restrictions. There is also some limited evidence that changes in excise taxes impact crime. There is only limited evidence that location and time restrictions on alcohol availability affect crime.[5]

The weak evidence for the location and time restriction policy can be explained in part by the different substitution mechanisms (Heaton, 2012). Any time and location restrictions do not prevent people from buying and consuming alcohol at other times and places. Additionally, if a specific form of alcohol is highly regulated people can buy and consume other types of alcohol with fewer restrictions. Thus, an alcohol policy with a single type of restriction on time, location, or product may not reduce actual alcohol availability.

In contrast, crime opportunity theories suggest that location and time restrictions on alcohol may impact crime because potential offenders and victims are unlikely to change their daily routine behaviors (Barr and Pease, 1990; Hakim and Rengert, 1981; Reppetto, 1976). When the opportunity structure changes so that offenders' marginal costs of committing a crime exceed the benefits, the overall amount of crime may be reduced, as offenders choose to postpone or substitute criminal behaviors (Clarke, 1995). If there are more people shopping or inebriated on Sunday, for example, this may provide a more target-rich environment for potential offenders seeking suitable victims.

Research on the relationship between crime and alcohol availability typically focuses on cross-sectional measures of alcohol-outlet density. Scribner and his colleagues showed that 1 more alcohol-outlet addition was associated with an increase in violent assaults in Los Angeles (Scribner et al., 1995), and an increase in homicide rates in New Orleans (Scribner et al., 1999). Gruenewald and colleagues (2006) reported that assaults were more common at off-premise than at on-premise establishments, but that a positive association between bar density and assault rates only occurred in low-income and rural communities in California. Gorman and colleagues found a significant relationship between alcohol outlets and violent crimes at a block level in Camden, New Jersey (Gorman et al., 2001), but no association at a municipality level in New Jersey (Gorman et al., 1998). Teh (2008) provided 1 of the few quasi-experimental studies of alcohol-outlet density and crime using data on the opening and closing of alcohol outlets in Los Angeles. The study found that openings were associated with an increase in crimes around stores located in low-SES neighborhoods only and that there was some evidence of crime displacement, but the displacement patterns differed by crime type and neighborhood SES.

In terms of the effect of temporal alcohol availability restrictions—for example, Sunday blue laws—studies show that changes in alcohol availability generally increase alcohol sales and consumption. Stehr (2007) reported that repealing a Sunday sales ban was significantly associated with

[2]In Pennsylvania, brewed alcohol beer is sold off-premise only in 6 packs at a limited numbers of pubs or dining places or in a keg or a case at off-premise alcohol distributors.

[3]The triple-difference design of the current study would at least partially difference away those effects of on-premise alcohol sales and of off-premise brewed alcohol sales on crime that were in common between before and after the repeal, Sunday and non-Sundays, and the treatment and control groups.

[4]See Appendix A for the test result table.

[5]The empirical studies on the effects of the traditional excise tax policy and the minimum-age restriction on crime are not covered in this paper's review. Carpenter and Dobkin (2011) provide a comprehensive review for these 2 restriction effects on crime.

increased sales of spirits due to increases in own-state drinking and cross-border shopping. Carpenter and Eisenberg (2009) reported that the 1997 repeal of alcohol-sales restrictions in Ontario, Canada, increased alcohol consumption on Fridays and Saturdays.

However, empirical evidence on other outcomes than alcohol sales and consumption is mixed. For example, 1 study found that repealing the New Mexico blue law brought about a significant increase in Sunday traffic fatalities (McMillan and Lapham, 2006), but another study did not find the association (Maloney and Rudbeck, 2009). With extended samples of multiple states, Stehr (2010) reported that the repeal of Sunday alcohol sales affected alcohol-related fatalities only in New Mexico and that the other states did not have any increase. Lovenheim and Steefel (2011) used a panel dataset of 15 states that repealed the blue laws between 1990 and 2009 and found that the Sunday blue laws had, at most, a small effect on fatal vehicle-accident rates. They noted that keeping Sunday alcohol-sales prohibitions tended to have only limited benefits on public health.

Studies investigating the effect of blue laws on crime are relatively rare. There are 3 notable Swedish studies on the effect of the changes in Saturday liquor sales on crime. Olsson and Wikström (1982) reported that a 3-month closure of the state-run liquor-store monopoly on Saturdays, which occurred in Sweden in 1981, reduced public-order crimes, domestic disturbances, and assaults. They also reported the possibility that crime was simply displaced from Saturdays to weekdays. In contrast, Norström and Skog (2003, 2005), using the repeal of the Saturday alcohol-sales ban in Sweden counties in 2000 and 2001, found no change in assaults on Saturdays, despite increases in alcohol sales and drunk driving. Grönqvist and Niknami (2014), revisiting the 2000 and 2001 Swedish Saturday ban repeal data, found significant increases in total and property crimes, although variations in violent crime were still not found to be significant.

Heaton (2012) provides the only published study that directly investigated the effects of the Sunday blue law repeal on crime in a U.S. setting. Capitalizing on the gradual repeal of Sunday off-premise liquor-sales bans in Virginia in 2004 and 2008 that was applied to only a set of cities and counties, he employed difference-in-differences (Sunday vs. the other days of week, and prerepeal vs. postrepeal) and DDD designs (adding Virginia jurisdictions that were affected by the repeals vs. those unaffected) to investigate crime changes at a jurisdiction level. He reported that the repeal led to significant increases in minor and serious alcohol-related crimes, but no increase in other general crimes in Virginia. He also concluded that there was no geographical or temporal displacement effect. However, the jurisdiction-level unit of observation may be too large to fully describe local dynamic effects on crime. Heaton's (2012) study tells us only that there was no evidence of crime displacement between jurisdictions and does not provide a test of whether crime moved within jurisdictions after the repeal.

Mechanisms: Off-Premise Alcohol Sales and Crime

Unlike on-premise alcohol sales, off-premise alcohol sales are often thought to be only loosely related with crime because people can buy the alcohol and consume it at a different time or location. However, off-premise alcohol sales may increase crime by being associated with both attraction and generation of crime. Crime pattern theory provides the typologies of "crime generator" and "crime attractor" to explain how the spatial congregation of people may lead to crime (Brantingham and Brantingham, 1993, 1995). Crime attractors draw motivated offenders to a location by increasing the number of would-be targets, while crime generators increase numbers of routine encounters between potential offenders and serendipitous crime opportunities. Crime attractors may simply redistribute from 1 location to another, such that the overall volume of crime stays largely unchanged in a jurisdiction. In contrast, crime generators increase the overall volume of crime of an area by making specific places more vulnerable for criminal offending.

Opening off-premise liquor stores on Sunday in commercial areas creates a large flow of population who visit the establishments and their adjacent neighborhood areas (Branas et al., 2009). This concentration of population generates serendipitous opportunities for thefts and for violent conflicts between people ("flow model" in Gruenewald [2007]). Also, the congregation of people may attract motivated offenders to open W&S store locations with a volume of suitable targets. If W&S stores were not open on Sunday, motivated offenders may have to search for suitable victims in other areas with greater time and effort.

There are other channels in which off-premise alcohol sales lead to immediate alcohol consumption and to crime. One channel is "Bring Your Own Beverage (BYOB)" restaurants that are prevalent in Pennsylvania due to the strict regulation of on-premise alcohol licenses. When these BYOB restaurants are located near W&S stores, people can buy wine or liquor from the off-premise stores to consume in restaurants. Another channel is a general pattern of recreational drinking around off-premise liquor stores. Even though off-premise liquor stores are not an ideal spot for immediate alcohol consumption, people may perceive alcohol outlets as a marker of social disorganization and want to consume alcohol around the stores ("social contextual model" in Gruenewald [2007]). Also, homeless individuals may buy cheap liquor from Sunday-open W&S stores with money received from begging and consume it on the streets immediately after purchasing.

Those who consume alcohol may be more likely to commit public-order offenses. Intoxicated individuals may lose self-control, mistakenly interpret social cues from others and react violently, or may be less careful and fall victim to criminal perpetrators (Branas et al., 2009; Gruenewald, 2007; Gruenewald et al., 2006). Intoxicated individuals may become more myopic, thus increasing the risk for criminal offending (Felson and Burchfield, 2004; Felson et al., 2008).

MATERIALS AND METHODS

Data Sources

The Philadelphia Police Department provided data on crime incidents that occurred between January 1, 1998, and December 31, 2011, in Philadelphia (a total of 1,086,694 separate crime incidents for 5,113 days). Each incident contained XY coordinates, type of crime, and the exact date of the police incident report. Only 1.4% (N = 15,438) of cases were removed due to missing location information. Seven individual crimes were classified into 4 aggregated categories of violent (homicide, robbery, and aggravated assault), property (burglary and all thefts), misdemeanors (disorderly conduct and public drunkenness), and total crimes (sum of all 7 crime types).

The PLCB provided data on all 94 Pennsylvania W&S stores that ever existed in Philadelphia from 1998 to 2011. The data included information on whether and when each store was allowed to open and sell liquor on Sundays, store IDs, location addresses, store business openings and closings, and store relocations. Among the 94 stores, 25 W&S stores belonged to a treatment group that ever had the Sunday-open permission, and 69 to a control group that never were allowed to open on Sundays. Census tract-level median household income data were obtained from the decennial 2000 census for areas in which W&S stores were located during the 14-year period.

Variables

The unit of observation reflects the number of crime incidents occurring within a 1/8-mile radius around each W&S store each day. The 1/8-mile distance was chosen because it is a common distance measure used in city planning as a reasonable walking distance from a location (for example, see Gorham et al., 2009). Two expanded radii areas (1/8 to 1/4-mile and 1/4 to 1/2-mile) were also examined for an analysis of crime displacement. When W&S stores had partially overlapped radii and an incident fell within the overlapped area, the crime incident was assigned to the closest store.[6]

The key independent variable was the triple-difference measure capturing whether the date was before or after the repeal date; whether the day was a Sunday; and whether the W&S store was allowed to sell liquor on Sundays, which is explained in detail in the following section.

Covariates were added to control for potential confounding factors and to improve precision in the estimates. Month-year fixed-effect indicators were included to control for secular changes that occurred equivalently to all W&S stores. Store fixed-effect indicators were added to control for store-specific unobservable factors that are constant over time. A dichotomous measure of holidays and their eves was also included as a covariate, as daily routines may vary by holidays that might artificially inflate a store's effect on crime.[7]

In addition, the entire sample of stores were split into high- versus low-SES neighborhood census tracts depending on whether the tract was above or below the median household income of $50,110 in inflation-adjusted 2011 dollars—the nationwide 2011 median household income estimates (DeNavas-Walt et al., 2013).

[6]For all 94 W&S stores, the overlapped incident proportions of crimes were 3.9% for the 1/8-mile distance; 10.2% for the 1/8- to 1/4-mile distance; and 20.1% for the 1/4- to 1/2-mile distance.

[7]Following the definition of holidays in Pennsylvania Statute Title 47 (§1-102), the holidays included New Year's Day, Dr. Martin Luther King Jr. Day, President's Day, Memorial Day, Independence Day, Labor Day, Thanksgiving Day, and Christmas Day. We also added St. Patrick's Day and Halloween to these statute-specific holidays, having no difference in results.

Identification Strategy

To estimate the effect of repealing the off-premise Sunday liquor-sales prohibition on crime around W&S stores, we specified a DDD model that compared the changes in crime (i) *before* versus *after* the repeal, (ii) near the *Sunday-open* versus *Sunday-closed* W&S stores, and (iii) occurring on *Sundays* versus *the other days of the week*. We performed data analyses using Stata 13 (StataCorp LP, College Station, TX) and ArcGIS 10.1 (Esri, New York, NY) software.

Given that crime data were measured in counts, we estimated a Poisson regression model, as Eq. (1). Each W&S store was denoted by i, while t denoted each of 5,113 days from 1998 to 2011 (t = 1/1/1998…, 12/31/2011), and j denoted a day of the week (j = Sun, Mon, Tue,…, Sat). A dichotomous variable, *Treat,* was assigned to 1 if a W&S store was allowed to open and sell liquor on Sundays after the date of the law change, and to zero if the store was not. This indicator variable represented the before versus after the repeal and Sunday-open versus Sunday-closed W&S stores differences simultaneously. The indicator variable *Sun* was assigned to 1 if the day of the week was Sunday and to zero otherwise. Its parameter (β_2) controls for any systematic difference in crime occurring on Sundays compared to other days of the week. The indicator variable *Treat*Sun* represented the triple difference, and the parameter from this term (β_3) was the key focus of our identification. Store and month-year fixed effects are also included in the model to control for time stable differences between stores and secular trends common to all stores. Standard errors were adjusted for clustering at the store level to control for autocorrelation (Bertrand et al., 2004).

$$Y_{ijt}(Crime) = \beta_0 + \beta_1 \cdot Treat_{it} + \beta_2 \cdot Sun_j + \beta_3 \cdot Treat * Sun_{itj} + \gamma_1 \cdot Store_i + \gamma_2 \cdot Month_Year + \gamma_3 \cdot Holiday_t + \varepsilon_{ij} \quad (1)$$

This model has 2 practical identification problems with the current data. First, a number of Philadelphia W&S stores experienced new business opening, closing, and relocations during the study period. These store-level business changes might impact crime variations. Second, the Sunday-open permission grant was solely at the discretion of PLCB, and there were noticeable variations in the permission grants given in Philadelphia. Among the 25 Philadelphia W&S stores that ever received the Sunday-open permission for the 14 years, only 6 W&S stores consistently maintained the permission to stay open throughout the period.[8]

To address the issue of W&S store movements and attrition, the current study employed 2 analysis strategies. First, we counted only the days when each W&S store was actually open for business during the study period and independently counted relocated W&S stores. Therefore, each of the 94 W&S stores that were ever open in Philadelphia during the 14-year period with distinct addresses represented an unbalanced number of days in the data. Second, to assess how the unbalanced nature of the current panel data influenced our estimates, we conducted a subgroup analysis by narrowing the dataset to 31 W&S stores that had never experienced any new business opening, closing, or additional Sunday-open permission changes after February 9, 2003, throughout the period. These 31 W&S stores in the reduced dataset included 6 Sunday-open W&S stores and 25 Sunday-closed ones. We present results from both all 94 W&S stores and the reduced dataset of 31 stores.

[8]Appendix B reports the variation in detail.

Table 1. Types and Numbers of Crime Incidents, According to Days of the Week

	On all days of the week	On Sundays	Sunday shares of crime incidents
Crime incidents occurring across Philadelphia between 1998 and 2011			
Total Crime	1,071,256 [100%]	139,647 [100%]	13.0%
Violent Crime	267,299 [25.0%]	40,278 [28.8%]	15.1%
Homicide	5,644	956	16.9%
Aggravated Assault	129,612	21,051	16.2%
Robbery	132,043	18,271	13.8%
Property Crime	733,573 [68.5%]	88,927 [63.7%]	12.1%
Burglary	159,351	18,961	11.9%
All Thefts	574,222	69,966	12.2%
Misdemeanor	70,384 [6.6%]	10,442 [7.5%]	14.3%
Disorderly Conduct	65,343	9,735	14.9%
Public Drunkenness	5,041	707	14.0%
Crime incidents occurring within the 1/8-mile radius surrounding all 94 W&S stores			
Total Crime	79,222 [100%]	9,705 [100%]	14.6%
Violent Crime	16,134 [20.4%]	2,354 [24.3%]	16.2%
Homicide	253	41	17.1%
Aggravated Assault	6,395	1,096	12.8%
Robbery	9,486	1,217	11.4%
Property Crime	57,379 [72.4%]	6,539 [67.4%]	12.6%
Burglary	8,036	1,015	11.2%
All Thefts	49,343	5,524	14.2%
Misdemeanor	5,709 [7.2%]	812 [8.4%]	15.3%
Disorderly Conduct	4,741	724	9.1%
Public Drunkenness	968	88	14.6%
Crime incidents occurring within the 1/8-mile radius surrounding the reduced dataset of 31 W&S stores			
Total Crime	34,038 [100%]	4,221 [100%]	12.4%
Violent Crime	6,572 [19.3%]	932 [22.1%]	14.2%
Homicide	114	18	16.0%
Aggravated Assault	2,700	448	16.6%
Robbery	3,758	466	12.4%
Property Crime	25,429 [74.7%]	2,978 [70.6%]	11.7%
Burglary	3,753	479	12.8%
All Thefts	21,676	2,499	11.5%
Misdemeanor	2,037 [6.0%]	311 [7.4%]	15.3%
Disorderly Conduct	1,731	282	16.3%
Public Drunkenness	306	29	9.5%

Percentages in brackets indicate shares of given crime categories' incident numbers over the total crime incident numbers.

RESULTS

Descriptive Statistics

Descriptive statistics are provided for both all 94 stores and the reduced 31 store dataset in Table 1. The upper part of the table provides the overall distribution of crimes. Overall, more than a million crime incidents occurred across the city during that period. One-quarter of incidents were violent crimes, while about two-thirds were property offenses. The "all thefts" property-crime category comprised half the total crime incidents. Thirteen percent of crimes occurred on Sundays. This overall crime distribution pattern was similar for the 1/8-mile radius surrounding all 94 W&S stores and the reduced dataset of 31 stores (the middle and lower parts of Table 1, respectively).

The DDD Results

Table 2 reports the DDD estimates in terms of average marginal effects for the blue law repeal effects on crime for both the entire 94 and the reduced 31 store datasets. For presentation reasons, we only display the coefficients from the DDD estimates, although the other variables are included in the models.[9] With the current DDD identification, effects are expected to be small, given that effects are estimated on a daily basis representing 3-times-differenced outcomes.

The first row in Table 2 denotes the DDD estimates of the ban repeal effect on crimes for all 94 W&S stores. All the coefficients were statistically insignificant at the 5% level, because of the relatively large standard errors. The large standard errors might be attributed to the facts that two-thirds of the 94 W&S stores were not granted Sunday-open permissions and that the ban repeal effect was estimated with an unbalanced dataset. Therefore, overall power to detect an effect might be relatively muted.

The results for the reduced 31 W&S store dataset in the lower row of Table 2 show relatively large and significant

[9]The regression results with the full set of coefficients are available upon request.

Table 2. Difference-in-Difference-in-Differences (DDD) Estimates of the Blue Law Repeal Effect on Crimes in Terms of Average Marginal Effects

	Total crime	Violent crime	Property crime	Misdemeanor
(1) β_1 for the entire	0.015	0.006	0.011	0.0005
dataset (N = 322,499)	(0.017)	(0.004)	(0.011)	(0.005)
(25 T and 69 C groups)	[1.063]	[1.131]	[1.063]	[1.026]
(2) β_1 for the reduced	0.035*	0.007	0.024*	0.005
dataset (N = 158,503)	(0.016)	(0.005)	(0.011)	(0.004)
(6 T and 25 C groups)	[1.179]	[1.188]	[1.159]	[1.470]

The unit of analysis is an 1/8-mile radius surrounding a W&S store per day. Coefficients in cells indicate DDD estimates of relevant crime incident increases on Sunday for the Sunday-open W&S stores after the "Blue laws" ban repeal. They are expressed in terms of an average marginal effect, being derived from respective Poisson regressions. The store-level clustered standard errors are provided in parentheses. Incidence rate ratios (IRR) are provided in brackets for percentage change information. For the statistical significance, *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

changes at the 5% level for total and property crimes. Total crime incidents on average increased by 0.035 incidents on Sunday within the 1/8-mile radius surrounding the Sunday-open W&S stores after the blue law ban repeal, while property crimes increased by 0.024 incidents (when measured as average marginal effects). Violent crime and misdemeanor increases did not reach the 5% significance. Therefore, the blue law repeal had a modest effect on total and property crimes in the immediate vicinity of the Sunday-open 6 W&S stores that were continuously in existence and subject to the repeal. The coefficients from the entire 94 and the reduced 31 store datasets were not significantly different,[10] confirming that the lack of significance in the entire 94 store analysis may be driven by the muted effect from the unbalanced panel.

Table 3 and Fig. 1 provide descriptive evidence of why the total crime increase was significant for the reduced 31 W&S store dataset. Table 3 compares the average daily numbers of total crime incidents between the treatment and control groups. Values in the cells indicate raw average number of crime incidents occurring within the 1/8-mile radius surrounding the W&S stores for each day, depending on given days of the week (Sunday or non-Sunday) during given periods (pre- or postrepeal) for given groups (treatment or control).[11] The postrepeal period tends to have a lower volume of average daily incidents than the prerepeal period, but the magnitude of crime drop was smaller on Sundays around treatment group W&S stores, compared to control group stores and compared to non-Sundays.

Figure 1 shows the trends of average daily numbers of total crime incidents by year occurring on Sundays (dark) and non-Sundays (light) within the 1/8-mile radius surrounding both the treatment (solid) and control (dotted) group W&S stores. The average gap between the treatment and control groups is relatively small before the repeal and increases after. However, the divergence in trends does not occur on non-Sundays. This graph provides visual depiction of the DDD estimates.

The Geographical Displacement Effect[12]

Although the findings in Table 2 suggest some evidence of crime increase effects of the ban repeal for the reduced dataset of 31 W&S stores, they do not address the policy-relevant question of whether an increase in alcohol availability produces a net increase in crime or just displaces crime to nearby areas. To address this question, the current study expanded the radius threshold from an 1/8-mile to a 1/4-mile and to a 1/2-mile. To clarify any potential movement of crime, crime incidents occurring within the 1/8-mile and 1/4-mile radii around the W&S stores were removed from these extended radii. Therefore, crime counts occurring *between* 1/8- and 1/4-miles and *between* 1/4- and 1/2-miles radii around the W&S stores were additionally examined for displacement.[13]

Table 4 reports the DDD estimate results for crime incidents occurring in the extended areas for the entire 94 W&S store dataset. For the comparison purpose, the first row of the table repeats the 1/8-mile radius DDD estimates that were reported in Table 2. The results show little evidence of geographical displacement of crime incidents. Table 5 shows the results for the reduced 31 W&S store datset. Again, there is no clear pattern of crime displacement.

Table 6 reports the results for geographical displacement in high- and low-SES neighborhoods for all 94 W&S stores. For the high-SES neighborhoods, there is no pattern of crime displacement. For low-SES neighborhoods, W&S stores increase crime nearby but do not appear to displace crime from distances out to a 1/2-mile.

Table 7 shows the results for the reduced dataset of 31 W&S stores. Violent crime incidents occurring between the 1/8- and 1/4-mile radii from the Sunday-open W&S stores significantly increased in low-SES neighborhoods, while violent crime patterns between the 1/4- and 1/2-mile radii decreased significantly. The differences between these 2 coefficients are statistically significant ($z = 3.24$; $p < 0.01$), suggesting that there was some violent crime displacement that occurred when stores were open on Sundays in low-SES neighborhoods. Figure 2 depicts this displacement effect of violent crime incidents. None of the other crime changes is statistically different, suggesting that in low-SES neighborhoods the Sunday opening of the stores on average increased crime in the area.

[10]For example, for the total crime, $Z = (0.015 - 0.035)/\text{SQRT}((0.017)^2 + (0.016)^2) = -0.85671$, which does not reach $Z = -1.96$ (Paternoster et al., 1998).

[11]The denominators were 1,865 days (prerepeal) and 3,248 days (postrepeal), respectively.

[12]In addition, no intertemporal displacement effects on Saturdays and Mondays were detected. The intertemporal displacement results are available upon request.

[13]Note again that crimes occurring beyond the ½-mile radius from the W&S stores are not identified in the current paper.

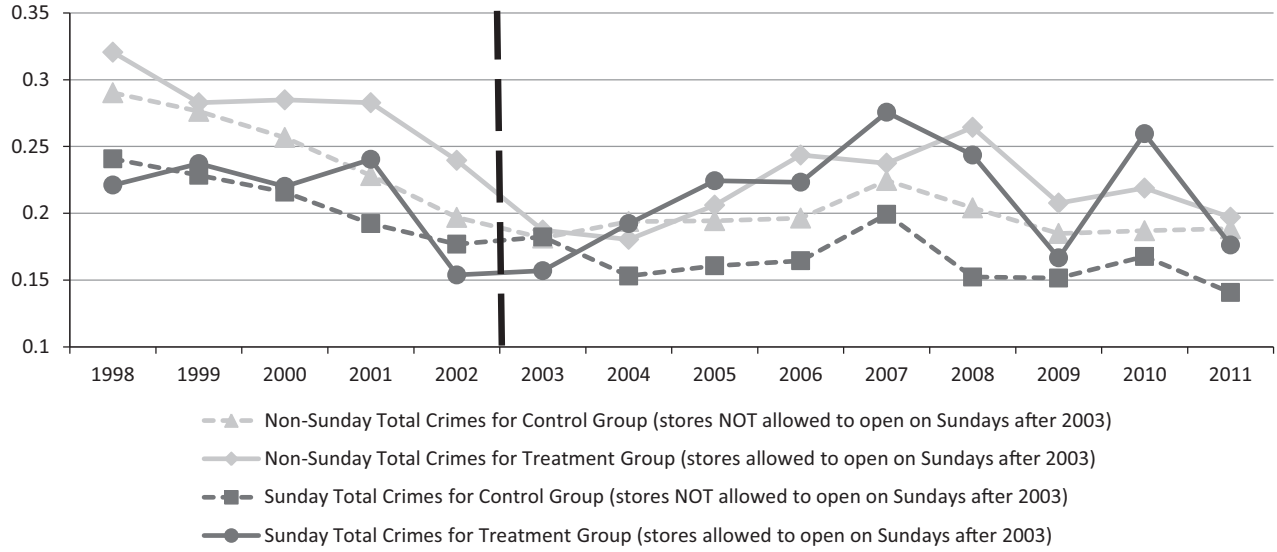

Fig. 1. Average daily total crime incidents by year occurring within 1/8-mile radius surrounding the reduced 31 W&S store dataset. The vertical line between the years of 2002 and 2003 roughly indicates the quasi-experiment timing (February 9, 2003 on which the Sunday liquor sales ban was repealed for those 31 W&S stores). The solid lines represent the treatment group's total crime trends while the dotted lines represent the control group's total crime trends. The light color stands for the non-Sunday total crime trends while the dark one stands for the Sunday total crime trends.

Table 3. Average Daily Total Crime Incidents Occurring Within 1/8-Mile Radius Surrounding the Reduced 31 W&S Store Dataset

	Treatment group: 6 W&S stores that were allowed to open on Sundays since Feb. 9, 2003			Control group: 25 W&S stores that were not allowed to open on Sundays since Feb. 9, 2003		
	Prerepeal (1/1/98 to 2/8/03)	Postrepeal (2/9/03 to 12/31/11)	Pre versus Post difference	Prerepeal (1/1/98 to 2/8/03)	Postrepeal (2/9/03 to 12/31/11)	Pre versus Post difference
Total crimes						
On Sundays	0.216	0.212	−0.004	0.208	0.164	−0.044
On non-Sundays	0.280	0.216	−0.064	0.247	0.196	−0.051
Violent crimes						
On Sundays	0.037	0.031	−0.006	0.043	0.043	0.000
On non-Sundays	0.038	0.032	−0.006	0.045	0.042	−0.003
Property crimes						
On Sundays	0.178	0.154	−0.024	0.148	0.110	−0.038
On non-Sundays	0.227	0.170	−0.057	0.188	0.142	−0.046
Misdemeanors						
On Sundays	0.008	0.021	+0.013	0.017	0.011	−0.006
On non-Sundays	0.015	0.014	−0.001	0.014	0.011	−0.003

These average daily numbers of crime incidents are calculated based on 5,113 days, of which the prerepeal period was 1,865 days from 1/1/1998 to 2/8/2003 and the postrepeal period was 3,248 days from 2/9/2003 to 12/31/2011. A value in a cell represents an average number of crime incidents.

Robustness Checks and Sensitivity Tests

We conducted several robustness tests for the DDD models. All the robustness checks' results are provided in Appendix C. We arbitrarily reassigned the opening day from Sunday to Tuesday. This falsification model yielded no statistically significant increase, implying that the repeal effect on crime in low-SES neighborhoods was specific to Sunday. We also compared Sundays to only Fridays or Saturdays, as drinking may increase on Fridays and Saturdays as people begin their weekend. The significant association between the repeal and total crime increase within the 1/8-mile radius remains significant in this comparison. We also compared the results when we removed adjacent days (Saturdays and Mondays) that may reflect temporal spillover effects from Sunday. The relative increase in crime around Sunday-open stores holds. Specifications of these models with negative binomial regressions were similar to those of the Poisson regressions estimated.

Finally, we performed a permutation test for the estimates shown for the low-SES neighborhoods (Bertrand et al., 2004), reported in Appendix D. We randomly shuffled crime outcomes to be independent of store-opening dates and re-estimated the model, and repeated this procedure 500 times. If our estimated coefficient (β_3) of *Treat* was real and not obtained just by statistical chance, the estimated coefficient we obtained should be located at the

Table 4. Geographical Displacement Effect for All 94 W&S Stores (N = 322,499) (25 Treatment and 69 Control Groups): Difference-in-Difference-in-Differences (DDD) Estimates of the Blue Law Repeal Effect on Crime in Terms of Average Marginal Effects

	Total crime	Violent crime	Property crime	Misdemeanor
(1) Within 1/8-mile radius	0.015	0.006	0.011	0.0005
	(0.017)	(0.004)	(0.011)	(0.005)
	[1.063]	[1.131]	[1.063]	[1.026]
(2) Between 1/8- and 1/4-mile radii	0.024	−0.002	0.013	0.013*
	(0.028)	(0.004)	(0.018)	(0.006)
	[1.053]	[0.981]	[1.039]	[1.409]
(3) Between 1/4- and 1/2-mile radii	0.028	0.005	0.029	0.009
	(0.020)	(0.010)	(0.015)	(0.008)
	[1.027]	[1.017]	[1.042]	[1.131]

The unit of analysis is a relevant mile radius surrounding a W&S store per day. The "between 1/8- and 1/4-mile radii" refers to the doughnut-shaped 1/4-mile radius that hollows a 1/8-mile radius area within them. In the same vein, the "between 1/4- and 1/2-mile radii" refers to the doughnut-shaped 1/2-mile radius that hollows a 1/4-mile radius area within them. Coefficients in cells indicate DDD estimates of relevant crime incident increases on Sunday for the Sunday-open W&S stores after the blue law ban repeal. They are expressed in terms of an average marginal effect, being derived from respective Poisson regressions. The store-level clustered standard errors are provided in parentheses. Incidence rate ratios (IRR) are provided in brackets for percentage change information. For the statistical significance, *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

Table 5. Geographical Displacement Effect for the Reduced Dataset of 31 W&S Stores (N = 158,503) (6 Treatment and 25 Control Groups): Difference-in-Difference-in-Differences (DDD) Estimates of the Blue Law Repeal Effect on Crime in Terms of Average Marginal Effects

	Total crime	Violent crime	Property crime	Misdemeanor
(1) Within 1/8-mile radius	0.035*	0.007	0.024*	0.005
	(0.016)	(0.005)	(0.011)	(0.004)
	[1.179]	[1.188]	[1.159]	[1.470]
(2) Between 1/8- and 1/4-mile radii	0.008	0.002	0.011	0.004
	(0.020)	(0.007)	(0.013)	(0.007)
	[1.020]	[1.028]	[1.038]	[1.164]
(3) Between 1/4- and 1/2-mile radii	0.003	−0.010	0.027	0.0001
	(0.019)	(0.018)	(0.021)	(0.007)
	[1.004]	[0.956]	[1.045]	[1.001]

See the note in Table 4.

extreme edge of the distribution of our 500 shuffled coefficients estimated. The p-values from these permutation tests show that the estimates for the increases in total crime and misdemeanor incidents occurring within the 1/8-mile radius surrounding the W&S stores in the low-SES neighborhoods are robust.

DISCUSSION

In the current study, we found that the repeal of the Pennsylvania Sunday off-premise liquor-sales ban was associated with increases in total and property crimes around W&S stores on Sundays in Philadelphia in low-SES neighborhoods. There appeared to be no effect on violent crime. We also found no consistent pattern of the displacement of

Table 6. Geographical Displacement Patterns for All 94 W&S Stores Located in the High- versus Low-Socioeconomic-Status (SES) Neighborhoods

	Total crime	Violent crime	Property crime	Misdemeanor
High-SES neighborhoods for 29 W&S stores (N = 109,136) (10 treatment and 19 control groups)				
(1) Within 1/8-mile radius	−0.037	−0.003	−0.016	−0.014***
	(0.022)	(0.004)	(0.015)	(0.003)
	[0.834]	[0.904]	[0.903]	[0.432]
(2) Between 1/8- and 1/4-mile radii	−0.020	−0.005	−0.030	−0.002
	(0.038)	(0.003)	(0.020)	(0.007)
	[0.939]	[0.890]	[0.880]	[0.939]
(3) Between 1/4- and 1/2-mile radii	0.004	−0.006	0.007	0.007
	(0.020)	(0.011)	(0.020)	(0.009)
	[1.007]	[0.938]	[1.016]	[1.186]
Low-SES neighborhoods for 65 W&S stores (N = 213,363) (15 treatment and 50 control groups)				
(1) Within 1/8-mile radius	0.045*	0.011	0.025*	0.010*
	(0.018)	(0.006)	(0.012)	(0.004)
	[1.182]	[1.196]	[1.142]	[1.717]
(2) Between 1/8- and 1/4-mile radii	0.043*	0.002	0.042*	0.008
	(0.033)	(0.007)	(0.017)	(0.007)
	[1.083]	[1.018]	[1.117]	[1.228]
(3) Between 1/4- and 1/2-mile radii	0.041	0.012	0.039	0.009
	(0.031)	(0.014)	(0.020)	(0.013)
	[1.032]	[1.031]	[1.046]	[1.114]

Coefficients in cells indicate DDD estimates of relevant crime incident increases on Sunday for the Sunday-open W&S stores after the blue law ban repeal, derived from respective Poisson regressions. The high-/low-SES neighborhoods were identified depending on whether an inflation-adjusted median house income of a census 2000 tract in which a W&S store was located was higher than $50,110 in 2011 dollars. Store-level clustered standard errors are provided in parentheses. Incidence rate ratios (IRR) are provided in brackets for percentage change information. For the statistical significance, *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

Table 7. Geographical Displacement Patterns for the Reduced Dataset of 31 W&S Stores Located in the Low- Versus High-Socioeconomic-Status (SES) Neighborhoods

	Total crime	Violent crime	Property crime	Misdemeanor
High-SES neighborhoods for 12 W&S stores (N = 61,356) (4 treatment and 8 control groups)				
(1) Within 1/8-mile radius	−0.002	−0.002	0.012	−0.018**
	(0.013)	(0.005)	(0.007)	(0.006)
	[0.986]	[0.915]	[1.098]	[0.142]
(2) Between 1/8- and 1/4-mile radii	−0.018	−0.006	−0.001	−0.015*
	(0.025)	(0.005)	(0.019)	(0.007)
	[0.925]	[0.847]	[0.994]	[0.259]
(3) Between 1/4- and 1/2-mile radii	0.013	−0.005	0.015	0.005
	(0.025)	(0.014)	(0.032)	(0.009)
	[1.026]	[0.947]	[1.039]	[1.253]
Low-SES neighborhoods for 19 W&S stores (N = 97,147) (2 treatment and 17 control groups)				
(1) Within 1/8-mile radius	0.061**	0.013	0.031	0.014***
	(0.021)	(0.007)	(0.016)	(0.003)
	[1.276]	[1.291]	[1.186]	[2.512]
(2) Between 1/8- and 1/4-mile radii	0.035*	0.014*	0.020	0.016***
	(0.015)	(0.006)	(0.012)	(0.004)
	[1.072]	[1.141]	[1.058]	[1.656]
(3) Between 1/4- and 1/2-mile radii	−0.013	−0.021*	0.029**	−0.001
	(0.026)	(0.009)	(0.011)	(0.012)
	[0.989]	[0.934]	[1.038]	[0.982]

See the note in Table 6.

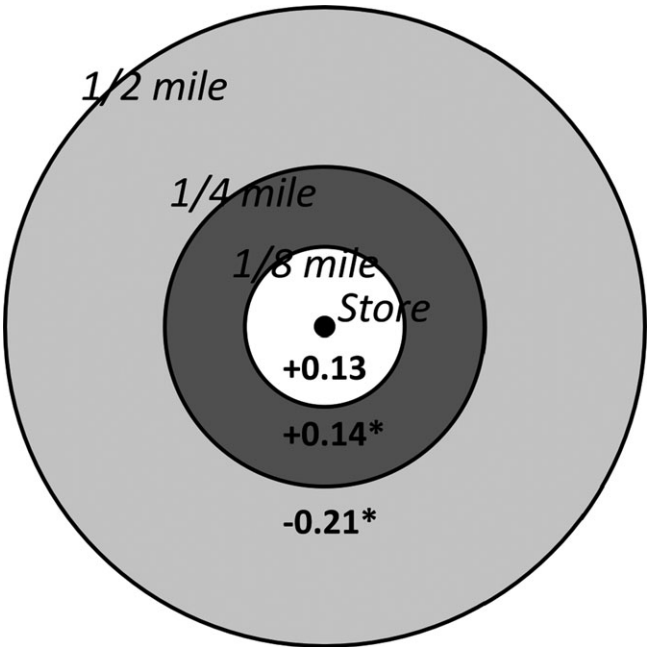

Fig. 2. Graphical description of the ban repeal effect on violent crime incidents for the reduced dataset of 19 W&S stores located in the low-socioeconomic-status neighborhoods. The center point stands for a treatment group (Sunday-open) W&S store. The smallest circle around the center point indicates the 1/8-mile radius from the store, the middle circle the 1/4-mile radius, and the largest circle the 1/2-mile radius. The values within or between the circles are the estimated average marginal effects extracted from the lower part of Table 7. The *s next to the average marginal effects indicate the corresponding statistical significances, $*p < 0.05$; $**p < 0.01$; $***p < 0.001$.

crime. These results are in line with other studies that find changing alcohol availability influences crime (Grönqvist and Niknami, 2014; Norström and Skog, 2003, 2005).

In addition, this study shows that the Sunday repeal's impact on increased crime was specific to low-SES neighborhoods only, many of which had already above average rates of crime. These findings are consistent with previous studies that find alcohol availability is most likely to influence crime in poverty-stricken environments (Gruenewald et al., 2006; Teh, 2008).

Regarding the unit of analysis, it is notable that this study shows the importance of micro-spatial point-based analyses in alcohol-crime studies, especially when crimes are distributed in spatially heterogeneous patterns that do not follow preexisting polygon boundaries, such as census tracts and ZIP codes (Geronimus, 2006). Relying on large jurisdictional boundaries minimizes one's ability to examine how alcohol availability impacts the spatial patterns of crime within jurisdictions. Here, we are able to complement work that used similar quasi-experimental designs (e.g., Grönqvist and Niknami, 2014; Heaton, 2012; Norström and Skog, 2003, 2005), but with a more refined spatial analysis. Future work would benefit from examining the impact of alcohol availability on even more fine-grained spatial analyses, such as point and radial distances.

The current study has limitations. Most notably, the main results were based only on off-premise W&S stores in Philadelphia and only based on identifying alcohol availability on Sundays. Alcohol can also be purchased in Philadelphia in bars and restaurants, and we cannot address the extent to which availability was practically constrained. We also did not have data to examine whether crimes that did increase were the result of alcohol consumption or simply the gathering of more people near open W&S stores on Sundays in poor neighborhoods. In terms of external validity, our estimates were confined to only a single major U.S. city and should be replicated in other contexts.

The current study uniquely contributes to the crime-alcohol literature with a focus on the locality of crimes and the triple-differences analysis. The triple-differences design provides more precise estimates of the effects of the changes in blue laws on local crime patterns than have been previously examined. We were also able to more precisely examine how, if at all, crime is displaced by changes in alcohol availability, using multiple small-radius buffer areas around the point locations of liquor stores. The findings suggest that the repeal of blue laws may generate increases in crime in urban areas that are poor where alcohol availability is a contributor to crime.

ACKNOWLEDGMENT

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APPENDIX A

We regressed Sunday-open permission grants (=1 if granted, =0 otherwise) on total crime and store-level average total crimes occurring prior to permit granting, using the entire 94 W&S store dataset with crime incidents occurring within the 1/8-mile radius of stores. Table A1 provides the logistic regressions results. The coefficients for both total crime before the grant (Model 1) and average total crime level around stores (Model 2) were statistically insignificant, with *p*-values of 0.501 and 0.496, respectively, suggesting that the Sunday-open permission grants were not predicted by total crime or its variation between stores.

Table A1. Prediction of Sunday-Open Permission Granting by Crime Trend and Level

	Model 1	Model 2
Total crime variation prior to permit granting	0.125 (0.186) [*p*-value = 0.501]	–
Average total crime level prior to permit granting	–	0.650 (0.955) [*p*-value = 0.496]
Pseudo R^2	0.0010	0.0052

N = 129,520. Coefficients are from logit regressions. Clustered-robust standard errors are provided in parenthesis. *p*-values are provided in brackets.

APPENDIX B

Table B1. Variations in Numbers (#) of All and Sunday-Open W&S Stores in Philadelphia

	Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Change in business operation	# of total stores as of Jan. 1	77	73	71	68	65	65	65	63	62	60	59	58	57	54
	# of openings that year	0	3	0	2	2	4	1	2	0	0	1	0	2	0
	# of closings that year	4	5	3	5	2	4	3	3	2	1	2	1	5	0
Change in Sunday-open permission	# of Sunday-open stores as of Jan. 1	0	0	0	0	0	0	8	8	15	16	15	15	18	19
	# of new permissions that year	0	0	0	0	0	8	0	8	2	0	0	3	5	1
	# of permission repeals that year	0	0	0	0	0	0	0	1	1	1	0	0	4	0

APPENDIX C

Table C1. Robustness Checks: Alternative Difference-in-Difference-in-Differences (DDD) Estimates for Total Crime Incidents Occurring in the Low-Socioeconomic-Status (SES) Neighborhoods

	For the entire dataset of stores in the low-SES neighborhoods (65 stores, N = 213,363)			For the reduced dataset of stores in the low-SES neighborhoods (19 stores, N = 97,147)		
Total Crime	Within an 1/8-mile radius	Between 1/8- and 1/4-mile radii	Between 1/4- and 1/2-mile radii	Within an 1/8-mile radius	Between 1/8- and 1/4-mile radii	Between 1/4- and 1/2-mile radii
(1) Original model: Estimate by Poisson regressions (from Table 4 and 5)	0.045* (0.018)	0.043* (0.033)	0.041 (0.031)	0.061** (0.021)	0.035* (0.015)	−0.013 (0.026)
(2) "Tuesday" as the false affected day (falsification test)	−0.003 (0.012)	−0.024 (0.013)	−0.028 (0.033)	−0.018* (0.008)	−0.024 (0.017)	−0.038 (0.050)
(3) Estimate when comparing Sundays versus Friday and Saturday	0.037* (0.018)	0.034 (0.021)	0.049 (0.025)	0 .045*** (0.015)	−0.001 (0.020)	−0.009 (0.017)
(4) Estimate when removing days adjacent to Sunday (removing Saturday and Monday)	0.049* (0.020)	0.049* (0.022)	0.046 (0.035)	0.071** (0.025)	0.038* (0.018)	0.002 (0.036)
(5) Estimate by negative binomial regressions	0.042* (0.019)	0.040* (0.020)	0.043 (0.031)	0.059** (0.021)	0.033* (0.014)	−0.012 (0.027)

See the note in Table 4. All the other coefficients (2~5) are from separate regressions and stand for estimates of changes in crime incident numbers per day in terms of average marginal effects. For the statistical significance, *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

APPENDIX D

Table D1. p-Values of Permutation Tests for W&S Stores in the Low-Socioeconomic-Status (SES) Neighborhoods

	Total crime	Violent crime	Property crime	Misdemeanor
For the entire dataset of stores in the low-SES neighborhoods (N = 213,363) (15 treatment and 50 control groups)				
(1) Within 1/8-mile radius	p = 0.000 (***)	p = 0.034 (*)	p = 0.000 (***)	p = 0.000 (***)
(2) Between 1/8- and 1/4-mile radii	p = 0.012 (*)	p = 0.720	p = 0.007 (***)	p = 0.000 (**)
(3) Between 1/4- and 1/2-mile radii	p = 0.124	p = 0.413	p = 0.046 (*)	p = 0.163
For the reduced dataset of stores in the low-SES neighborhoods (N = 97,147) (2 treatment and 17 control groups)				
(1) Within 1/8-mile radius	p = 0.000 (***)	p = 0.081	p = 0.122	p = 0.038 (*)
(2) Between 1/8- and 1/4-mile radii	p = 0.284	p = 0.363	p = 0.319	p = 0.041 (*)
(3) Between 1/4- and 1/2-mile radii	p = 0.806	p = 0.440	p = 0.488	p = 0.961

Values in cells indicate proportions of the shuffled DDD regression coefficients whose absolute values were greater than the absolute values of our estimated DDD coefficient, which means the 2-tailed p-values of the permutation tests. For the statistical significance, *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.