Opening Hours and Consumer Behavior: Evidence from GPS Data and Deregulation*

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Abstract

In 2019, North Dakota repealed its Sunday closing law, which had required most non-grocery stores to close between midnight and noon. Using this policy change and consumer GPS data, we study the impact of opening hours on shopping behavior and welfare. We compare visits before and after the repeal in North Dakota and neighboring states using difference-in-differences and event-study designs. The repeal caused a large increase in Sunday morning visits, originating partly from intertemporal, store-type, and cross-border substitution. The closing law's welfare loss is equivalent to increasing the travel distance to affected stores by about 1.4 miles per consumer.

JEL: L81, L51, D12

Keywords: consumer behavior, opening hours, store choices, deregulation, GPS data

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1 Introduction

Store opening hours are regulated in many countries to either protect workers, promote fair competition between large and small businesses, or preserve traditional weekend activities such as church attendance and family time. However, such restrictions also constrain consumer behavior. When stores are closed, consumers face restrictions and may have to adjust by shopping at less convenient times or at less convenient stores, traveling farther, or deferring purchases altogether. Despite the widespread use and political salience of the store opening hours regulation, relatively little is known about the costs to consumers.

In this paper, we study how store opening hours affect consumer shopping behavior and welfare. A major empirical challenge in studying this question is that firms optimally choose opening hours in response to their anticipated consumer demand. This creates a simultaneity problem: stores are open when consumers want to shop, and consumers shop when stores are open. To understand the causal impact of opening hours, one needs a setting where store opening hours vary exogenously relative to consumer preferences. To overcome this difficulty, we exploit a natural experiment: the repeal of North Dakota's Sunday closing law on August 1, 2019. Before the repeal, the law required most non-grocery stores to close between midnight and noon on Sundays, making it one of the strictest blue laws in the United States. The repeal removed this constraint, allowing stores, notably general merchandise stores such as Walmart, to open earlier on Sundays.

Specifically, in this paper we ask two main questions: *First*, what is the impact of store opening hour restrictions on consumer shopping behavior, i.e., do consumers respond by changing where and when they shop? *Second*, what are the welfare implications to consumers of the restriction?

To answer these questions, we use detailed Global Positioning System (GPS) data from mobile devices to track consumer visits to retail locations at an hourly frequency and at

the store level. The data, provided by Advan Research, are based on anonymized location information from a large panel of mobile phone applications.[1] The dataset records the number of visits to each store by hour of the week, allowing us to analyze Sunday morning shopping and substitution patterns. We also observe monthly visits to each store by the home census block group of visitors, enabling us to study travel distances. Our sample includes visits to stores in North Dakota and its neighboring states before and after the deregulation in 2019.

We focus our analysis on the largest general merchandise store chain, Walmart, and grocery stores. We do so for two reasons: first, while we do observe store visits before and after the policy change, we do not directly observe whether each store responded to deregulation by increasing the number of hours it was open. In the case of Walmart, we know that this was indeed the case, i.e., all stores in North Dakota were closed on Sunday mornings before deregulation and open on Sunday mornings after the deregulation. Second, Walmart operates many stores that are virtually identical across states, allowing us to use other states as a control group. We analyze visits to grocery stores because these were not directly affected by the regulation, as they were already allowed to be open on Sunday mornings before the policy change.

We first document the causal effect of deregulating Sunday morning store hours on consumer shopping behavior. Using difference-in-differences and event-study designs, we compare hourly store visit patterns before and after the repeal in North Dakota with those in neighboring states, where no regulatory change occurred. We find that the repeal led to a substantial increase in Sunday morning visits in North Dakota Walmart stores. We interpret this as evidence that restricting store hours does affect consumers.

Second, we examine how consumers adapt when shopping opportunities are restricted. If

[1]The mobility data were previously provided by Safegraph and transitioned to Advan Research in 2023. The SafeGraph data were widely used to study movements during COVID-19. The representativeness of the SafeGraph data has been evaluated by Chen and Pope (2020) and Athey et al. (2021).

an individual's favorite store is not open at the time when they would prefer to shop, what happens? Will they change to a new store? Shop at a different time? We find that the added flexibility to shop on Sunday mornings reshaped consumer behavior in three ways: across time, across space, and across store type. First, visits slightly declined on Sunday afternoons. Second, border Walmart stores in Minnesota saw fewer Sunday-morning visits, as North Dakota residents no longer had a reason to cross the state line. Third, grocery stores, which were exempt from the restrictions, experienced a drop in visits after the repeal.

To quantify the welfare implications of increased flexibility in shopping hours, we present a discrete choice model where consumers choose their preferred store and shopping time. The model captures preferences over shopping time, store type, and travel distance. To overcome the lack of pricing information across stores, we focus on travel distance as our main welfare metric. We find that the Sunday morning ban was welfare-equivalent to Walmart stores being about 1.4 miles further away for each consumer.

We make three novel contributions. First, we document the causal effect on consumer shopping behavior of repealing the blue law prohibiting Sunday morning sales. In doing that, we provide evidence of intertemporal and spatial substitution. Second, we quantify the value to consumers from the additional flexibility of choosing when to shop after the deregulation. We find that the consumer welfare loss due to the Sunday prohibition is equivalent to increasing the distance to the studied stores by 1.4 miles. Third, we use detailed geolocation data that have not been used before to analyze the impact of changes in regulation in the retail market.

Literature. Our paper is related to several strands of literature. First, we contribute to the literature on regulation and, in particular, store-hour regulation. Opening hours restrictions can have both social benefits and costs. Earlier empirical work has focused mainly on potential benefits, examining effects on employment (Skuterud, 2005; Paul, 2015; Bensnes

and Strom, 2019; Rizzica, Roma and Rovigatti, 2023) and church attendance (Gruber and Hungerman, 2008; Cohen-Zada and Sander, 2011).[2] These studies show that opening hours restrictions can protect workers and even strengthen community and religious practices. Less is known about the costs to consumers, such as the inconvenience from restricted store access. Measuring these costs is difficult because it requires data on shopping time and location at an hourly level. To the best of our knowledge, our paper is the first to use GPS data to study the impact of store-hour deregulation. Jacobsen and Kooreman (2005) use time diary data in the Netherlands to document that shopping activities shifted toward workday evenings after deregulation. Our GPS dataset allows us to study both shopping time and location choices. Moreover, as the policy change affected only certain types of stores in one state, we have natural control groups (neighboring states and other types of stores) that allow us to study the causal impact of the deregulation.

Our paper is also related to the literature using mobile phone location data to study consumer behavior.[3] The literature has analyzed preferences for restaurants (Athey et al., 2018; Charles, Guryan and Park, 2025) and cars (Yavorsky, Honka and Chen, 2021), racial segregation in consumption (Athey et al., 2021), and consumption externalities from remote work (Miyauchi, Nakajima and Redding, 2021). To the best of our knowledge, we are the first to use mobile phone location data to analyze the impact of retail deregulation.

We also contribute to the literature on store choice. The literature has documented how consumers choose stores based on prices (Bell and Lattin, 1998; Thomassen et al., 2017; Paciello, Pozzi and Trachter, 2019), convenience and distance (Taylor and Villas-Boas, 2016; Marshall and Pires, 2018; Eizenberg, Lach and Oren-Yiftach, 2021; Huang and Bronnenberg, 2023), product quality (Matsa, 2011), and other non-price characteristics (Smith, 2004, 2006;

[2]The literature has also looked at the impact of blue laws on alcohol consumption (Bernheim, Meer and Novarro, 2016; Hinnosaar, 2016).

[3]The literature using mobile phone location data has also studied other topics such as policing (Chen et al., 2023), voting (Chen et al., 2022), political protests (Sobolev et al., 2020), geographic mobility (Chen and Pope, 2020), and obility and economic activity (Kreindler and Miyauchi, 2023).

Trindade, 2015; Ellickson, Grieco and Khvastunov, 2020). We show that store opening hours are another important factor in store choice.[4]

Our paper is also related to the literature that focuses on the impact of discount stores on the grocery market. The literature has documented that upon entry, large discount stores take the market share from grocery stores.[5] This has been shown in the case of Walmart (Basker, 2007; Hausman and Leibtag, 2007; Ellickson and Grieco, 2013) and dollar stores (Caoui, Hollenbeck and Osborne, 2022) in the US, and discount stores in other countries (Evensen, Steen and Ulsaker, 2024).[6] We document a similar substitution effect toward Walmart, not through the entry of a new store, but through the extension of opening hours.

Our work is related to the literature quantifying the extent of cross-border shopping. The literature has mainly focused on cross-border shopping motivated by differences in prices (e.g., Campbell and Lapham (2004); Friberg, Steen and Ulsaker (2022)) or the regulations prohibiting the sale of certain products, like marijuana (Hansen, Miller and Weber, 2020).[7] Our work shows that the sales restrictions on most non-food products during certain hours also lead to cross-border shopping.

Our work also relates to the studies investigating the opportunity cost of time in grocery shopping.[8] The literature has shown that the opportunity cost of time changes over the business cycle (Nevo and Wong, 2019), at retirement (Aguiar and Hurst, 2005), and during

[4]The effect of temporary store closures has been studied by Kotschedoff, Kowalczyk and Breugelmans (2025).

[5]This is opposed to the documented positive externalities of department stores in malls (Gould, Pashigian and Prendergast, 2005), small stores in Dutch shopping streets (Koster, Pasidis and van Ommeren, 2019), and car dealerships (Murry and Zhou, 2020). Heterogeneous effects of store externalities have been shown by Vitorino (2012).

[6]Relatedly, Jia (2008) showed that in the 1980s and 1990s, the expansion of Walmart led to the exit of a large percentage of small discount stores. Similarly, Talamas Marcos (2025) showed that the entry of chain convenience stores had negative effects on independent convenience stores.

[7]Health and public economics literature has focused on cross-border shopping of alcohol and cigarettes driven by differences in taxes (Asplund, Friberg and Wilander, 2007; Harding, Leibtag and Lovenheim, 2012; Johansson, Pekkarinen and Verho, 2014; Hindriks and Serse, 2019).

[8]The literature on ride-hailing markets has studied intra-daily variation in the opportunity cost of time (Buchholz et al., 2025).

unemployment (Bronnenberg, Klein and Xu, 2024). We show that the opportunity cost of time also varies throughout a typical week.

2 Institutional Background and Natural Experiment

The Sunday closing laws, also known as blue laws, limit store opening hours or prohibit the sale of specific items on Sundays. Sunday closing laws aim to either protect workers, promote fair competition between large and small businesses, or preserve traditional weekend activities such as church attendance and family time. The arguments against these laws are typically based on consumer welfare.

The store opening-hour regulations have deep historical roots. In A.D. 321, the Roman Emperor Constantine issued the first known prohibition on Sunday labor, declaring: "On the venerable Day of the Sun let the magistrates and people residing in cities rest, and let all workshops be closed".[9]

Sunday closing laws remain widespread across European countries, including Germany, Austria, Switzerland, Norway, and the UK, among others, though recent decades have seen substantial reforms. In England, the Sunday closing laws were relaxed in 1994. Until then, on Sundays, large shops had to be closed; since then, large shops have been permitted to open up to six hours. A 2015-16 proposal to let local authorities set their own rules for Sunday store opening hours was rejected in Parliament. Germany deregulated weekday store opening hours in 2006, but on Sundays still requires most stores to be closed. Several countries lifted the Sunday restrictions in recent years, including Denmark in 2012, and Finland and Hungary in 2016. On the other hand, Poland introduced one of Europe's strictest bans in 2018, closing almost all stores on Sundays. In Portugal, large retailers have been allowed to open on Sunday since 2010, but the matter is still under public debate (as recently as June

[9]Source: `https://en.wikipedia.org/wiki/Blue_law`, accessed Aug 27, 2025.

2025, a bill was introduced in the national parliament attempting to force large retailers to close again on Sunday).

In the U.S., most of the laws that place a wide ban on commerce on certain days have been repealed. However, many states still restrict the hours during which alcohol can be sold or ban the sale of cars on Sundays. In 2019, North Dakota repealed one of the country's strictest blue laws.

Before August 1, 2019, most stores in North Dakota were required to close from midnight until noon on Sundays. Exceptions included grocery stores (supermarkets and convenience stores), drugstores, flower shops, newsstands, and gas stations. The law also prohibited the sale of most non-food items on Sunday before noon, including clothing, appliances, kitchenware, and toys. Notably, department stores and discount stores, like Walmart, had to be closed.

North Dakota lawmakers and the governor who supported the repeal of the Sunday closing law argued that it would allow people to spend money locally rather than online or in stores in other states, thereby increasing tax revenue and employment.[10] Anecdotal evidence suggests that until August 2019, many North Dakota residents did their shopping in Minnesota on Sundays. Shopping in Minnesota was viable for residents of two of the three largest North Dakota cities (Fargo and Grand Forks), which are located close to the border with Minnesota.

The Sunday closing law was a divisive issue in North Dakota. In the decade prior to the repeal, there were three unsuccessful attempts to repeal the law. The main reasons the repeal finally passed include a generational shift among lawmakers; the election of a new governor; the addition of a clause preventing leases or franchise agreements from requiring Sunday openings; increased pressure from border-city retailers; and a growing realization

[10]See e.g. https://www.usnews.com/news/best-states/articles/2019-03-26/north-dakotans-will-soon-be-able-to-shop-on-sunday-mornings and https://apnews.com/article/5c255da5b6f14414a8d1fe291a77ce77.

that the ban did not protect store employees who were already stocking shelves but merely prohibited customer-facing work, not Sunday work itself.[11] The 2019 repeal did not end the debate: in 2025, lawmakers considered reinstating similar restrictions, but the proposal was defeated.

The Sunday closing law repeal bill was signed in March 2019, and it took effect on August 1, 2019. Consumers were well aware of the change. In July, major retailers issued press releases listing their earlier Sunday opening hours. Local media reminded consumers that the first Sunday affected would be August 4, and published the new opening hours for the major retailers.

Retailers with nationwide opening-hour policies, such as Walmart, adjusted their North Dakota schedules to align with corporate policies. Before the repeal, North Dakota was the only state in which Walmart did not operate 24 hours a day. Beginning in August 2019, Walmart stores in North Dakota started to be open around the clock, just as they were elsewhere.[12] While large chains adjusted their hours, many independent stores did not. As we analyze how opening hours affect consumer behavior, we focus on Walmart to exploit the regulation-induced change in opening hours.

3 Data

Advan Research's mobility data. To measure shopping behavior, we use store-visit data based on GPS geo-location information from mobile phones provided by Advan Research: Advan Monthly Patterns (Advan Research, 2022*a*) and Advan Weekly Patterns (Advan Re-

[11] See e.g.: `https://news.prairiepublic.org/local-news/2019-01-14/senate-majority-leader-reconsidering-opposition-to-blue-law-repeal`

[12] See e.g. `https://www.inforum.com/business/retailers-setting-earlier-sunday-openings-as-n-d-s-shopping-blue-law-ends-in-august`.

search, 2022*b*).[13,14] The data are based on anonymized location information from a large panel of mobile phone applications. The applications track location with an accuracy of approximately 10 meters, and data collection occurs only with the explicit consent of the user.

The data consists of two separate aggregations of the mobile phone positioning information. First, it provides a store-level number of visits at a given hour of the week, for example, at 11 am on Sunday. This allows us to analyze temporal patterns of store visits. Second, it provides the store-level number of visits by consumer origin census block group. It allows us to analyze how shopping behavior depends on the distance to stores. Here, we do not observe the exact timing of the store visits. Instead, the data is aggregated across all hours. For each store, we also observe its location, associated chain, and industry code, which allows us to separate grocery stores.

Sample and variables. We focus on North Dakota and its neighboring states - Minnesota, South Dakota, and Montana - which we use as a control group. These states are shown in Figure 1, with North Dakota in blue and the comparison states in red. Our dataset includes visits to stores in 2019, before and after the deregulation. We focus on the largest general merchandise store chain, Walmart, for two reasons. First, the retailer adjusted its opening hours in response to the policy change. Second, it operates many stores that are virtually identical across states. As a substitute for Walmart, we analyze visits to grocery stores (supermarkets and convenience stores). These were stores that were not directly affected by the regulation, as they were allowed to remain open on Sunday mornings even before the repeal of the law. However, grocery stores can be affected via spillovers. We restrict attention

[13]This data was made available by Advan Research (`https://advanresearch.com/`) on the Dewey Data platform (`https://www.deweydata.io/`).

[14]According to Dewey, Advan's data is nearly identical in structure and quality to SafeGraph data, which was available in the past but transitioned to Advan in 2023, and which was widely used in prior research, especially to study movement patterns during COVID-19. The representativeness of SafeGraph data has been evaluated by Chen and Pope (2020); Athey et al. (2021).

to grocery store chains with at least ten stores in these four states because, compared to independent stores, they were more likely to be open on Sunday mornings.[15]

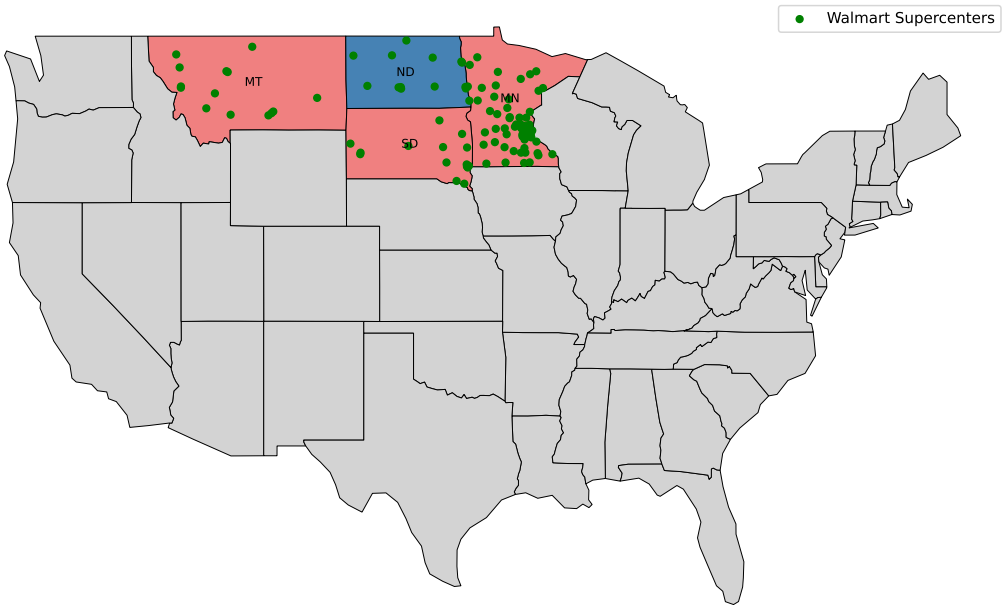


Figure 1: North Dakota and neighboring comparison states used in the analysis.

We define Sunday morning as the period from 6 am to noon. Although the policy also covered hours from midnight to 6 am, we exclude these because most detected visits during that time are likely to come from store employees rather than customers.[16] We define Sunday afternoon as 1 pm to 2 pm. This period is the closest natural substitute for morning shopping trips while avoiding overlap with them. In our data, the substitution effect is strongest in this early-afternoon window and diminishes rapidly thereafter, exactly as we would expect.

Summary statistics. The distribution of the percentage of store visits on Sunday mornings is in Figure 2. Before the reform, Walmart stores in North Dakota received a significantly smaller number of visits on Sunday mornings than stores in neighboring states (Figure 2a). Note that the average number of visits was close to, but not exactly, zero. This is because

[15]We filter out Walmart and grocery stores that operate at the same location using Shared Polygons data from Advan Research.

[16]We obtain similar results when including these hours in the morning definition.

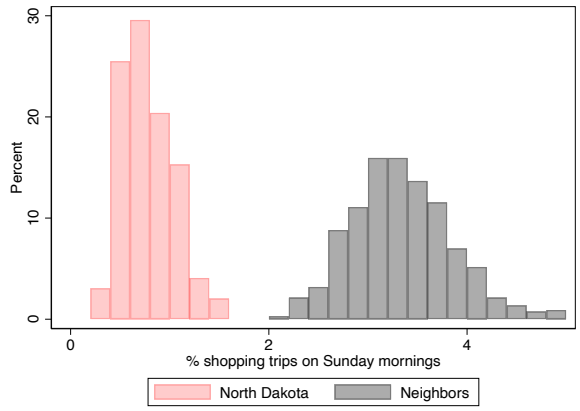
the data includes employees who were inside the stores even when the stores were closed to shoppers. After the reform, Walmart visits on Sunday morning increased, becoming more similar to those in neighboring states (Figure 2b). To rule out that the change in shopping behavior does not correspond to a specific change in consumer preferences in August, Figures 2c and 2d show that North Dakota consumers were shopping on Sunday mornings in grocery stores already before the reform, and the distribution is largely unaffected by the reform. Overall, the figures indicate that the Sunday morning restriction was binding for consumers. Table 1 reports summary statistics on store visits by store type and location prior to the reform.

Table 1: Summary statistics

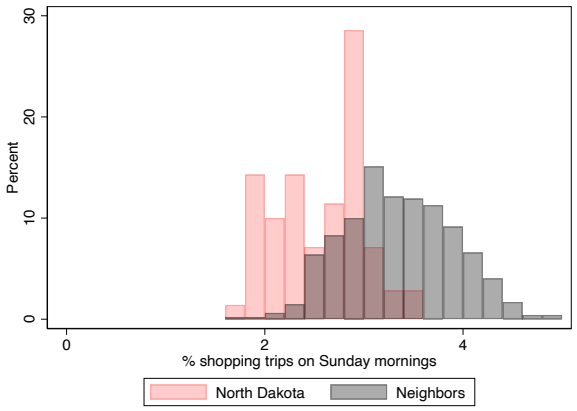
	North Dakota	Neighboring states
	(1)	(2)
	Panel A: Walmart stores	
Number of visits on Sunday mornings	91.5	368.7
Number of visits on Sunday afternoons	199.7	161.0
Number of visits per month	7856.1	7374.1
Number of unique visitors per month	3535.4	3500.0
Number of stores	14	92
	Panel B: Grocery stores	
Number of visits on Sunday mornings	33.6	46.2
Number of visits on Sunday afternoons	12.3	15.4
Number of visits per month	826.7	1000.3
Number of unique visitors per month	487.0	579.6
Number of stores	65	664
	At North Dakota border	Non-border
	(1)	(2)
	Panel C: Walmart stores in Minnesota	
Number of visits on Sunday mornings	310.5	380.6
Number of visits on Sunday afternoons	112.9	163.8
Number of visits per month	5235.9	7578.9
Number of unique visitors per month	2380.8	3653.4
Number of stores	2	63

Notes: The table reports average monthly statistics before the policy change (January to July 2019). In panel A, Walmart stores in neighboring states exclude two stores close to the North Dakota border. In panel B, grocery stores include both supermarkets and convenience stores.

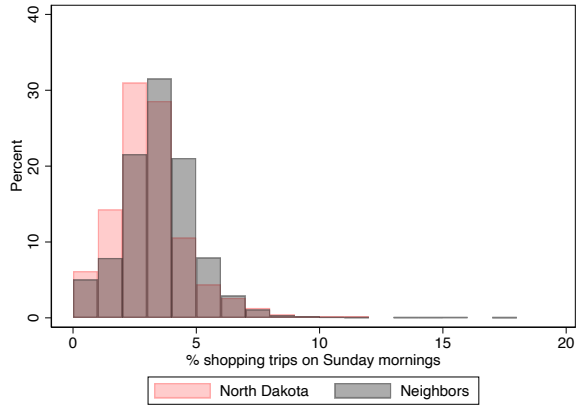
Figure 2: The distribution of the percentage of visits on Sunday mornings, separately for stores in North Dakota and neighboring states before and after the change in regulation



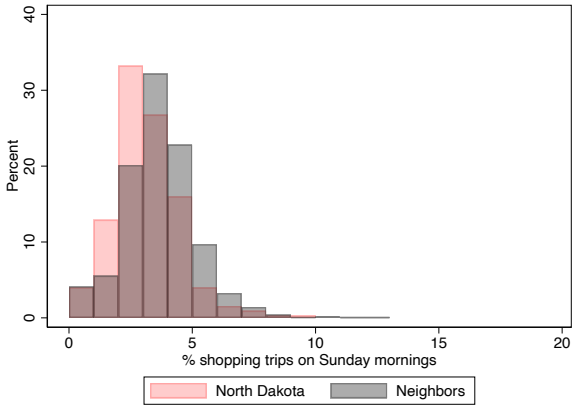
(a) Walmart stores before policy change



(b) Walmart stores after policy change



(c) Grocery stores before policy change



(d) Grocery stores after policy change

Notes: The figure presents the histogram of the percentage of shopping trips on Sunday mornings. An observation is a store-month pair.

4 Empirical Analysis

4.1 Empirical Strategy

Difference-in-differences. Our goal is to measure changes in consumer shopping behavior following the repeal of North Dakota's Sunday closing law. We estimate difference-in-differences regressions, comparing the change in store visits in North Dakota before and after the repeal to the corresponding change in neighboring states, where no such policy change occurred. We use difference-in-differences because a simple before-after comparison would ignore seasonal patterns that could bias the results. Our research design allows us to control for unobservable factors that are constant across all stores in a given month, or constant across all months in a given store.

Specifically, we estimate the following regression, where the outcome variable is the logarithm of the number of visits to store i in month t (or in specific hours or days):

$$\begin{aligned} logVisits_{it} = \beta \cdot NorthDakota_i \times AfterRepeal_t \\ + MonthFE_t + StoreFE_i + \varepsilon_{it}. \end{aligned} \tag{1}$$

The coefficient of interest is β, on the interaction term of the indicator whether the store is in North Dakota ($NorthDakota_i$) and the time period is after the repeal ($AfterRepeal_t$). It measures the change in the number of visits to the store i in North Dakota after the repeal of the Sunday closing law compared to the change in the number of visits in the neighboring states. The regression includes store and month fixed effects. We study the change in store visits on Sunday mornings, afternoons, and total visits.

Event study. To examine the dynamics of the policy effect and assess the validity of the parallel trends assumption, we complement the difference-in-differences analysis with an

event study specification. This approach estimates the evolution of treatment effects over time by interacting period-specific indicators with the treatment group indicator. We replace the post-treatment indicator with a full set of time relative-to-repeal dummies, allowing us to trace the trajectory of store visits before and after the policy change. We estimate event studies separately by time block (e.g., Sunday mornings and Sunday afternoons) to visualize substitution patterns over time.

4.2 Shopping Time Effects

We begin by analyzing how the extended store hours due to the repeal of the Sunday closing law affected the timing of store visits. Here we focus on Walmart stores only, as all Walmart stores are homogeneous and were directly affected by the Sunday sales restrictions. Table 2 reports the results from our difference-in-differences regressions (Equation (1)), where the outcome is the logarithm of the number of visits to a store in specific time blocks or the number of unique visitors in a month. For the former, we also present results controlling for the logarithm of the number of unique monthly visitors. This controls for changes in the sample of mobile devices in the dataset. The underlying assumption is that while the deregulation might have affected when and how often a consumer visits a particular store, it did not change whether a consumer visits the store at least once a month. All standard errors from the difference-in-differences and event-study specifications are clustered at the store level.

There is a substantial increase in visits on Sunday mornings following the repeal, indicating that the prior restriction was binding (the first two columns in Table 2). The increase is illustrated in the event study plot in Figure 3a, which shows a sharp upward shift in visits on Sunday morning. The results are robust to alternative functional forms, with the outcome variable in levels or normalized values (see Tables A.1 and A.2 in the Online Appendix). Table 2 also provides evidence of substitution over time, showing a decline in Sunday after-

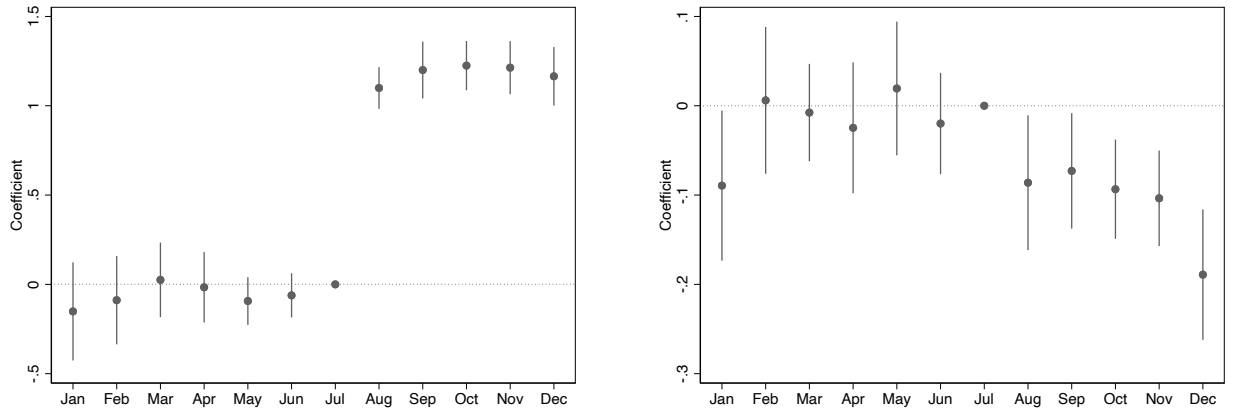
noon visits. The decline is statistically different from zero, although smaller in magnitude than the Sunday morning increase. It also shows that the policy change did not change the total number of unique visitors.

Table 2: Temporal effects

	Sunday mornings log visits		Sunday afternoons log visits		Monthly log visits		Monthly log visitors
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
North Dakota · Post	1.238***	1.236***	-0.090***	-0.092***	0.019	0.017**	0.003
	(0.062)	(0.064)	(0.018)	(0.016)	(0.012)	(0.007)	(0.012)
Log monthly unique visitors	No	Yes	No	Yes	No	Yes	No
Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Store FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Dep. var. levels mean in ND, <Aug	91.5	91.5	199.7	199.7	7856.1	7856.1	3535.4
Stores	105	105	105	105	105	105	105
Observations	1260	1260	1260	1260	1260	1260	1260

Notes: The dependent variable is the logarithm of visits and visitors in Walmart stores. The sample includes all Walmart stores in North Dakota and neighboring states, except the two border Walmart stores in Minnesota. Standard errors in parentheses are clustered at the store level. *** Indicates significance at the 1 percent level, ** 5 percent level, * 10 percent level.

Figure 3: Event study of the logarithm of the number of visits to Walmart stores in North Dakota versus neighboring states



(a) Sunday Morning

(b) Sunday Afternoon

Notes: The figures present point estimates and 95% confidence intervals from the event study regressions that include the logarithm of the number of unique monthly visitors. Standard errors in parentheses are clustered at the store level.

Taken as a whole, these results indicate that when Walmart stores were closed on Sunday mornings, a portion of consumers who would otherwise have shopped during that time shifted to shopping later in the day. Overall, this pattern of substitution reinforces the view that Sunday morning hours were valued, and the law was a binding constraint on consumer behavior.

4.3 Store Type Substitution

Our data allows us to explore two other types of substitution patterns arising from Walmart stores being closed on Sunday mornings. First, we examine whether consumers relocate their visits to different store types in response to the deregulation of opening hours. This can be the case because grocery stores were allowed to be open on Sunday mornings even before the change in policy, unlike Walmart stores. Table 3 (columns 1-2) and Figure 4a show that there is a substantial decrease in visits to stores that had a large number of Sunday morning visits before the policy change. We focus on this segment to guarantee that we are looking at food stores that are indeed open on Sunday morning (the fact that they *can* be open does not necessarily imply that they are open). Results suggest that consumers substituted to grocery stores when Walmart stores were closed on Sunday mornings, and are robust to alternative functional forms (see Tables A.3 and A.4 in the Online Appendix).

4.4 Cross-Border Substitution

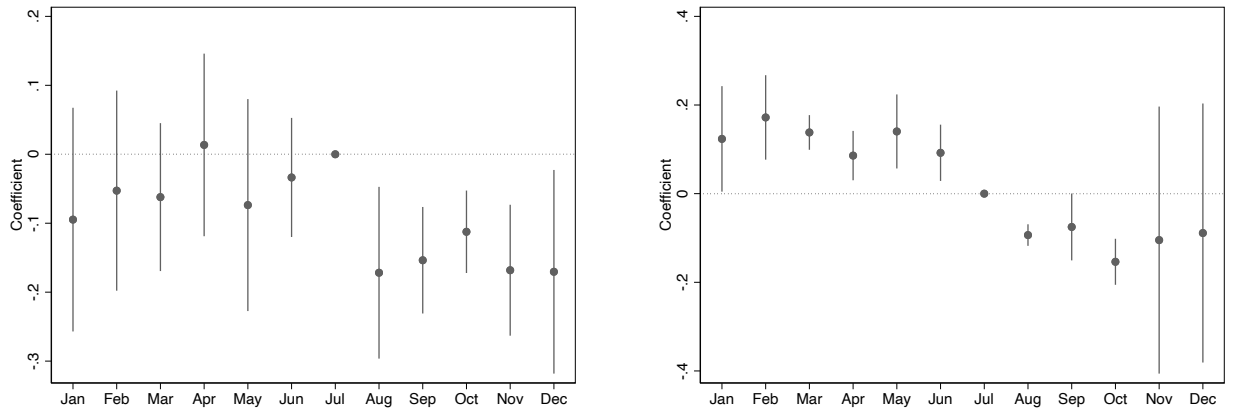
The second type of substitution we examine is spatial, specifically, cross-border shopping. This mechanism is relevant for the cities of Fargo and Grand Forks, the largest and third-largest cities in North Dakota, respectively. Both cities are located on the state border and form twin-city pairs with Moorhead, Minnesota (adjacent to Fargo) and East Grand Forks, Minnesota (adjacent to Grand Forks). Prior to the repeal of North Dakota's Sunday closing

Table 3: Substitution between stores

	Sunday mornings log visits				Monthly unique log visitors	
	>90th percentile		≤90th percentile		>90th	≤90th
	(1)	(2)	(3)	(4)	(5)	(6)
North Dakota · Post	-0.103**	-0.112***	-0.032	-0.028	0.009	-0.004
	(0.051)	(0.041)	(0.035)	(0.030)	(0.024)	(0.026)
Log monthly unique visitors	No	Yes	No	Yes	No	No
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Store FE	Yes	Yes	Yes	Yes	Yes	Yes
Dep. var. levels mean in ND, <Aug	164.4	164.4	20.3	20.3	1721.3	361.4
Stores	69	69	660	660	69	660
Observations	828	828	7920	7920	828	7920

Notes: Outcome variables are the logarithm of the number of visits (columns 1–4) and unique visitors (columns 5–6) in grocery stores. Columns 1–2 restrict the sample to the top 10% of stores with the largest number of Sunday morning visits before the policy change. Columns 3–4 restrict the sample to the remaining stores. Standard errors in parentheses are clustered at the store level. *** Indicates significance at the 1 percent level, ** 5 percent level, * 10 percent level.

Figure 4: Event study of the logarithm of the number of visits to stores on Sunday mornings



(a) Grocery stores: ND vs. neighbors

(b) Walmart in MN: bordering ND vs. others

Notes: The figures present point estimates and 95% confidence intervals from the event study regressions that include the logarithm of the number of unique monthly visitors. Standard errors in parentheses are clustered at the store level.

law, residents of these cities faced restricted shopping opportunities on Sunday mornings. Concurrently, stores across the border in Minnesota remained open. This made cross-border shopping a viable and convenient substitute. We discuss next how the removal of Sunday

restrictions in North Dakota affected cross-state substitution. The answer to this question is important, for example, for managers of franchise stores who may consider closing on Sunday while other stores from the same chain further away may remain open.

Table 4: Substitution across border

	Sunday mornings log visits		Monthly unique log visitors
	(1)	(2)	(3)
At North Dakota border · Post	-0.220**	-0.210**	-0.011
	(0.107)	(0.085)	(0.026)
Log monthly unique visitors	No	Yes	No
Month FE	Yes	Yes	Yes
Store FE	Yes	Yes	Yes
Dep. var. levels mean at border, <Aug	310.5	310.5	2380.8
Stores	65	65	65
Observations	780	780	780

Notes: Dependent variable is the logarithm of the number of visits and unique visitors in Walmart stores in Minnesota. Standard errors in parentheses are clustered at the store level. *** Indicates significance at the 1 percent level, ** 5 percent level, * 10 percent level.

Table 4 (columns 1-2) and Figure 4b show that Sunday morning visits to Walmart stores in Minnesota's border areas declined after the sales restrictions in North Dakota were lifted. They provide evidence of cross-border shopping substitution arising from the sales restriction. The results are robust to alternative functional forms (see Tables A.5 and A.6 in the Online Appendix).

5 Welfare Analysis

5.1 A Simple Model

Set-up. To quantify the welfare cost of Sunday morning sales restrictions, we build a model where consumers choose stores and shopping time. Each consumer i chooses between four alternatives: visiting a Walmart or a grocery store (which includes supermarkets and convenience stores), either on Sunday morning or at another time. We do not model consumers who don't regularly buy groceries or purchase them from other types of stores. For the model, we use data only from North Dakota. In North Dakota, focusing attention on Walmart and grocery stores is not too restrictive because there are not many other options for grocery shopping.

The utility of consumer i from shopping at a store of type $w = 1$ (Walmart) or $w = 0$ (grocery store) at time $t = 1$ (Sunday morning) or $t = 0$ (any other time) is:

$$U_{iwt} = \alpha D_{iw} + \beta t + \gamma w + \epsilon_{iwt}, \tag{2}$$

where D_{iw} is the distance from the consumer's home location to the nearest store of type w, and ϵ_{iwt} is an i.i.d. extreme value shock.

Using the standard approach, this model yields choice shares across the four alternatives. The share of consumer i's visits to store type w at time t is

$$s_{iwt} = \frac{\exp(\alpha D_{iw} + \beta t + \gamma w)}{\sum_{w'=0}^{1} \sum_{t'=0}^{1} \exp(\alpha D_{iw'} + \beta t' + \gamma w')}. \tag{3}$$

Welfare. With this model, we can compute the consumer welfare

$$W = \sum_{i \in I} W_i = \sum_{i \in I} \log \sum_{w,t} \exp(\alpha D_{iw} + \beta t + \gamma w), \tag{4}$$

where I is the set of all consumers.

Counterfactual. Our counterfactual is enacting a Sunday morning sales restriction, which removes the option $w = 1, t = 1$ for all consumers. Let W^{SM} be the welfare in this case. As we remove an option from the choice set, total welfare goes down, but our goal is to compute an interpretable magnitude of this change.

Specifically, we compute the compensating distance, which is a distance X such that moving Walmart stores away by an additional X miles is welfare-equivalent to the inconvenience consumers face due to Sunday sales restrictions. Let $W^D(X)$ be the welfare in this scenario, where all four options are available to all consumers, but their distance to Walmart is now $D_{i1} + X$ instead of D_{i1}. The compensating distance solves the equation $W^D(X) = W^{SM}$. Using the model assumptions, we find that the compensating distance is[17]

$$X = \frac{\log(1 + e^{\beta})}{-\alpha}. \tag{5}$$

5.2 Welfare Estimate

To get a numeric estimate for the compensating distance, we need the values of the three parameters (α, β, γ). First, using the share of shopping trips that consumer i takes to Walmart, s_{i1}, we get[18]

$$\log \frac{s_{i1}}{1 - s_{i1}} = \gamma + \alpha \Delta_i, \tag{6}$$

where $\Delta_i = D_{i1} - D_{i0}$ is the differential distance to the closest Walmart vs. the closest grocery store. This allows us to get estimates for the store-type preference parameter γ and the distance parameter α.

[17] The equation $W_i^D(X) = W_i^{SM}$ simplifies to

$$\exp(\alpha D_{i1} + \alpha X + \beta + \gamma) + \exp(\alpha D_{i1} + \alpha X + \gamma) = \exp(\alpha D_{i1} + \gamma) \iff e^{\alpha X}\left(1 + e^{\beta}\right) = 1.$$

[18] Derivations of expressions (6) and (7) are in Appendix B.

We estimate β using the share of Sunday morning visits to store j, s_{j1}, from

$$\log \frac{s_{j1}}{1 - s_{j1}} = \beta. \tag{7}$$

The estimate of the slope of the scaled market share of Walmart on the relative distance to Walmart (Figure A.1) implies $\widehat{\alpha} = -0.02$. The average logit-transformed share of Sunday morning visits (Figure A.2) implies $\widehat{\beta} = -3.54$. Inserting these numbers into Equation (5), we find that the compensating distance is approximately 1.4 miles.

5.3 Accounting for Cross-Border Shopping

The analysis above assumed that the Sunday closing law made it impossible to shop at Walmart on Sunday mornings. In practice, consumers can still go to Walmart in neighboring states. For some consumers, it means traveling a long distance, but for consumers living in border cities, the added inconvenience is relatively small. We can add this consideration to our analysis by replacing a Sunday sales restriction with a different counterfactual, where on Sunday morning Walmart's distance is $D_{i1} + Y_i$ instead of D_{i1}. Then the compensating distance is

$$X_i = \frac{1}{-\alpha} \log \left(\frac{1 + e^{\beta}}{1 + e^{\beta} e^{\alpha Y_i}} \right). \tag{8}$$

How big an impact the Sunday sales restriction has now depends on the location of the consumer i. Figure 5 shows that the new compensating distance X_i is increasing with the distance Y_i to the closest out-of-state Walmart. For the border areas, where the out-of-state Walmart is within 10-20 miles, the compensating distance is substantially lower than X computed above, but for most consumers in North Dakota, the X_i is quite close to X computed above, because the added travel distance makes it quite impractical to visit out-of-state Walmart stores.

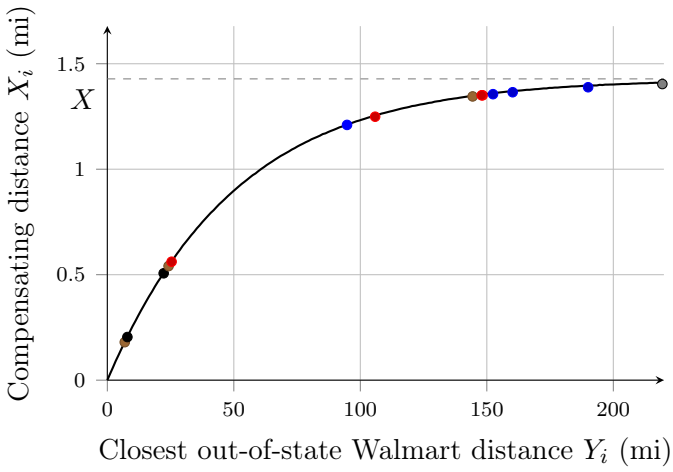


Figure 5: Compensating distances X_i for each Y_i. Each dot corresponds to a different Walmart in North Dakota, and the value in the Y_i is computed as the distance to the closest out-of-state Walmart.

6 Concluding Remarks

We studied the impact of store opening hour deregulation on consumer behavior and welfare using the 2019 repeal of North Dakota's Sunday closing law as a natural experiment. We showed that lifting the restriction led to a substantial increase in Sunday morning visits. We documented intertemporal substitution, substitution across store types, and cross-border substitution.

Our evidence shows that Sunday-morning trading restrictions impose real costs on consumers, even where alternative shopping options exist. To quantify the welfare implications of the regulation, we presented a framework to model consumers' preferences over the three documented dimensions: time, store type, and distance. The welfare analysis suggests that deregulating Sunday morning store hours is equivalent to a decrease in the travel distance to Walmart stores by 1.4 miles for each consumer.

It is worth emphasizing that this welfare analysis captures only the consumer side of the policy's effects. We do not analyze potential changes in firm behavior, such as pricing, product variety, investment, or labor-market outcomes. Our findings measure only one side

of the policy's impact, while all the above factors are important for the overall welfare.

Our findings have important implications for both policymakers and store managers. Policymakers face a trade-off: restrictions may help maintain a shared day of rest and can benefit small retailers or workers seeking more convenient schedules, but they also reduce flexibility for time-constrained households and may shift spending to other jurisdictions. Our paper provides clear evidence regarding how consumers are affected by such regulations. Likewise, managers have to decide the days and time slots in which they will be open to the public. They also need to decide whether to have a uniform chain-wide policy or to allow each store to have a separate policy. Understanding how many visits they will lose if the store is closed on Sunday, and if those visits are lost to competitors or just relocated to other days of the week, is a crucial input into a manager's store hour policy.

References

Advan Research. 2022*a*. "Foot Traffic / Monthly Patterns [Dataset]." *Dewey Data*, https://doi.org/10.82551/BEB1-2831.

Advan Research. 2022*b*. "Foot Traffic / Weekly Patterns [Dataset]." *Dewey Data*, https://doi.org/10.82551/X1PP-1F65.

Aguiar, Mark, and Erik Hurst. 2005. "Consumption versus Expenditure." *Journal of Political Economy*, 113(5): 919–948.

Asplund, Marcus, Richard Friberg, and Fredrik Wilander. 2007. "Demand and distance: Evidence on cross-border shopping." *Journal of Public Economics*, 91(1): 141–157.

Athey, Susan, Billy Ferguson, Matthew Gentzkow, and Tobias Schmidt. 2021. "Estimating experienced racial segregation in US cities using large-scale GPS data." *Proceedings of the National Academy of Sciences*, 118(46).

Athey, Susan, David Blei, Robert Donnelly, Francisco Ruiz, and Tobias Schmidt. 2018. "Estimating Heterogeneous Consumer Preferences for Restaurants and Travel Time Using Mobile Location Data." *AEA Papers and Proceedings*, 108: 64–67.

Basker, Emek. 2007. "The Causes and Consequences of Wal-Mart's Growth." *Journal of Economic Perspectives*, 21(3): 177–198.

Bell, David R., and James M. Lattin. 1998. "Shopping Behavior and Consumer Preference for Store Price Format: Why "Large Basket" Shoppers Prefer EDLP." *Marketing Science*, 17(1): 66–88.

Bensnes, Simon S., and Bjarne Strom. 2019. "Earning or Learning? How Extending Closing Time in the Retail Sector Affects Youth Employment and Education." *Oxford Bulletin of Economics and Statistics*, 81(2): 299–327.

Bernheim, B. Douglas, Jonathan Meer, and Neva K. Novarro. 2016. "Do Consumers Exploit Commitment Opportunities? Evidence from Natural Experiments Involving Liquor Consumption." *American Economic Journal: Economic Policy*, 8(4): 41–69.

Bronnenberg, Bart J., Tobias J. Klein, and Yan Xu. 2024. "Consumer Time Budgets and Grocery Shopping Behavior." *Management Science*, 70(3): 1596–1612.

Buchholz, Nicholas, Laura Doval, Jakub Kastl, Filip Matejka, and Tobias Salz. 2025. "Personalized Pricing and the Value of Time: Evidence From Auctioned Cab Rides." *Econometrica*, 93(3): 929–958.

Campbell, Jeffrey R., and Beverly Lapham. 2004. "Real Exchange Rate Fluctuations and the Dynamics of Retail Trade Industries on the U. S.-Canada Border." *American Economic Review*, 94(4): 1194–1206.

Caoui, El Hadi, Brett Hollenbeck, and Matthew Osborne. 2022. "The Impact of Dollar Store Expansion on Local Market Structure and Food Access." SSRN Scholarly Paper 4163102, Rochester, NY.

Charles, Kerwin Kofi, Jonathan Guryan, and Kyung H. Park. 2025. "Consumer sentiment towards Asians in the early days of the Covid-19 pandemic." *Journal of Public Economics*, 247: 105396.

Chen, M. Keith, and Devin G. Pope. 2020. "Geographic Mobility in America: Evidence from Cell Phone Data." NBER Working Paper 27072.

Chen, M. Keith, Kareem Haggag, Devin G. Pope, and Ryne Rohla. 2022. "Racial Disparities in Voting Wait Times: Evidence from Smartphone Data." *The Review of Economics and Statistics*, 104(6): 1341–1350.

Chen, M. Keith, Katherine L. Christensen, Elicia John, Emily Owens, and Yilin Zhuo. 2023. "Smartphone Data Reveal Neighborhood-Level Racial Disparities in Police Presence." *The Review of Economics and Statistics*, 1–29.

Cohen-Zada, Danny, and William Sander. 2011. "Religious Participation versus Shopping: What Makes People Happier?" *The Journal of Law and Economics*, 54(4): 889–906.

Eizenberg, Alon, Saul Lach, and Merav Oren-Yiftach. 2021. "Retail Prices in a City." *American Economic Journal: Economic Policy*, 13(2): 175–206.

Ellickson, Paul B., and Paul L. E. Grieco. 2013. "Wal-Mart and the geography of grocery retailing." *Journal of Urban Economics*, 75: 1–14.

Ellickson, Paul B., Paul L.E. Grieco, and Oleksii Khvastunov. 2020. "Measuring competition in spatial retail." *The RAND Journal of Economics*, 51(1): 189–232.

Evensen, Charlotte B, Frode Steen, and Simen A Ulsaker. 2024. "Co-Location, Good, Bad, or Both: How do New Entries of Discount Variety Stores Affect Local Grocery Businesses?" *Journal of the European Economic Association*, 22(4): 1798–1843.

Friberg, Richard, Frode Steen, and Simen A. Ulsaker. 2022. "Hump-Shaped Cross-Price Effects and the Extensive Margin in Cross-Border Shopping." *American Economic Journal: Microeconomics*, 14(2): 408–438.

Gould, Eric D., B. Peter Pashigian, and Canice J. Prendergast. 2005. "Contracts, Externalities, and Incentives in Shopping Malls." *The Review of Economics and Statistics*, 87(3): 411–422.

Gruber, Jonathan, and Daniel M. Hungerman. 2008. "The Church Versus the Mall: What Happens When Religion Faces Increased Secular Competition?" *The Quarterly Journal of Economics*, 123(2): 831–862.

Hansen, Benjamin, Keaton Miller, and Caroline Weber. 2020. "Federalism, partial prohibition, and cross-border sales: Evidence from recreational marijuana." *Journal of Public Economics*, 187: 104159.

Harding, Matthew, Ephraim Leibtag, and Michael F. Lovenheim. 2012. "The Heterogeneous Geographic and Socioeconomic Incidence of Cigarette Taxes: Evidence from Nielsen Homescan Data." *American Economic Journal: Economic Policy*, 4(4): 169–98.

Hausman, Jerry, and Ephraim Leibtag. 2007. "Consumer benefits from increased competition in shopping outlets: Measuring the effect of Wal-Mart." *Journal of Applied Econometrics*, 22(7): 1157–1177.

Hindriks, Jean, and Valerio Serse. 2019. "Heterogeneity in the tax pass-through to spirit retail prices: Evidence from Belgium." *Journal of Public Economics*, 176: 142–160.

Hinnosaar, Marit. 2016. "Time inconsistency and alcohol sales restrictions." *European Economic Review*, 87: 108–131.

Huang, Yufeng, and Bart J. Bronnenberg. 2023. "Consumer Transportation Costs and the Value of E-Commerce: Evidence from the Dutch Apparel Industry." *Marketing Science*, 42(5): 984–1003.

Jacobsen, Joyce P., and Peter Kooreman. 2005. "Timing constraints and the allocation of time: The effects of changing shopping hours regulations in The Netherlands." *European Economic Review*, 49(1): 9–27.

Jia, Panle. 2008. "What Happens When Wal-Mart Comes to Town: An Empirical Analysis of the Discount Retailing Industry." *Econometrica*, 76(6): 1263–1316.

Johansson, Per, Tuomas Pekkarinen, and Jouko Verho. 2014. "Cross-border health and productivity effects of alcohol policies." *Journal of Health Economics*, 36: 125–136.

Koster, Hans R. A., Ilias Pasidis, and Jos van Ommeren. 2019. "Shopping Externalities and Retail Concentration: Evidence from Dutch Shopping Streets." *Journal of Urban Economics*, 114: 103194.

Kotschedoff, Marco J. W., Liliana Kowalczyk, and Els Breugelmans. 2025. "The persistence of grocery shopping behavior and retailer choice: Evidence from a major labor strike." *Quantitative Marketing and Economics*.

Kreindler, Gabriel E., and Yuhei Miyauchi. 2023. "Measuring Commuting and Economic Activity inside Cities with Cell Phone Records." *The Review of Economics and Statistics*, 105(4): 899–909.

Marshall, Guillermo, and Tiago Pires. 2018. "Measuring the Impact of Travel Costs on Grocery Shopping." *The Economic Journal*, 128(614): 2538–2557.

Matsa, David A. 2011. "Competition and Product Quality in the Supermarket Industry." *The Quarterly Journal of Economics*, 126(3): 1539–1591.

Miyauchi, Yuhei, Kentaro Nakajima, and Stephen J. Redding. 2021. "The Economics of Spatial Mobility: Theory and Evidence Using Smartphone Data." National Bureau of Economic Research Working Paper 28497.

Murry, Charles, and Yiyi Zhou. 2020. "Consumer Search and Automobile Dealer Colocation." *Management Science*, 66(5): 1909–1934.

Nevo, Aviv, and Arlene Wong. 2019. "The Elasticity of Substitution Between Time and Market Goods: Evidence from the Great Recession." *International Economic Review*, 60(1): 25–51.

Paciello, Luigi, Andrea Pozzi, and Nicholas Trachter. 2019. "Price Dynamics with Customer Markets." *International Economic Review*, 60(1): 413–446.

Paul, Annemarie. 2015. "After work shopping? Employment effects of a deregulation of shop opening hours in the German retail sector." *European Economic Review*, 80: 329–353.

Rizzica, Lucia, Giacomo Roma, and Gabriele Rovigatti. 2023. "The Effects of Deregulating Retail Operating Hours: Empirical Evidence from Italy." *The Journal of Law and Economics*, 66(1): 21–52.

Skuterud, Mikal. 2005. "The impact of Sunday shopping on employment and hours of work in the retail industry: Evidence from Canada." *European Economic Review*, 49(8): 1953–1978.

Smith, Howard. 2004. "Supermarket Choice and Supermarket Competition in Market Equilibrium." *The Review of Economic Studies*, 71(1): 235–263.

Smith, Howard. 2006. "Store characteristics in retail oligopoly." *The RAND Journal of Economics*, 37(2): 416–430.

Sobolev, Anton, M. Keith Chen, Jungseock Joo, and Zachary C. Steinert-Threlkeld. 2020. "News and Geolocated Social Media Accurately Measure Protest Size Variation." *American Political Science Review*, 114(4): 1343–1351.

Talamas Marcos, Miguel Ángel. 2025. "Surviving Competition: Neighbourhood Shops versus Convenience Chains." *The Review of Economic Studies*, 92(1): 553–585.

Taylor, Rebecca, and Sofia B. Villas-Boas. 2016. "Food Store Choices of Poor Households: A Discrete Choice Analysis of the National Household Food Acquisition and Purchase Survey (FoodAPS)." *American Journal of Agricultural Economics*, 98(2): 513–532.

Thomassen, Øyvind, Howard Smith, Stephan Seiler, and Pasquale Schiraldi. 2017. "Multi-category Competition and Market Power: A Model of Supermarket Pricing." *American Economic Review*, 107(8): 2308–2351.

Trindade, Andre. 2015. "Price and Variety in Supermarkets: Can Store Competition Hurt Consumers?" SSRN Scholarly Paper 1878830, Rochester, NY.

Vitorino, Maria Ana. 2012. "Empirical Entry Games with Complementarities: An Application to the Shopping Center Industry." *Journal of Marketing Research*, 49(2): 175–191.

Yavorsky, Dan, Elisabeth Honka, and Keith Chen. 2021. "Consumer search in the U.S. auto industry: The role of dealership visits." *Quantitative Marketing and Economics*, 19(1): 1–52.

Appendix

A Additional Figures and Tables

Table A.1: Temporal effects. Visits and visitors in Walmart stores

	Sunday mornings visits		Sunday afternoons visits		Monthly visits		Monthly visitors
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
North Dakota · Post	207.670***	204.080***	-14.535***	-15.724***	222.349	154.513**	42.006
	(34.986)	(31.795)	(4.165)	(3.825)	(153.194)	(74.965)	(71.965)
Monthly unique visitors	No	Yes	No	Yes	No	Yes	No
Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Store FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Dep. var. levels mean in ND, <Aug	91.5	91.5	199.7	199.7	7856.1	7856.1	3535.4
Stores	105	105	105	105	105	105	105
Observations	1260	1260	1260	1260	1260	1260	1260

Notes: Standard errors in parentheses are clustered at the store level. *** Indicates significance at the 1 percent level, ** 5 percent level, * 10 percent level.

Table A.2: Temporal effects. Logarithm of normalized visits in Walmart stores

	Sunday mornings log visits		Sunday afternoons log visits		Monthly log visits	
	(1)	(2)	(3)	(4)	(5)	(6)
North Dakota · Post	1.249***	1.246***	-0.091***	-0.093***	0.020	0.017**
	(0.063)	(0.064)	(0.018)	(0.016)	(0.012)	(0.008)
Log monthly unique visitors	No	Yes	No	Yes	No	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Store FE	Yes	Yes	Yes	Yes	Yes	Yes
Dep. var. levels mean in ND, <Aug	1292.4	1292.4	2826.9	2826.9	110998.1	110998.1
Stores	105	105	105	105	105	105
Observations	1260	1260	1260	1260	1260	1260

Notes: Standard errors in parentheses are clustered at the store level. *** Indicates significance at the 1 percent level, ** 5 percent level, * 10 percent level.

Table A.3: Substitution between stores. Visits and visitors in grocery stores

	Sunday mornings visits				Monthly unique visitors	
	>90th percentile		≤90th percentile		>90th	≤90th
	(1)	(2)	(3)	(4)	(5)	(6)
North Dakota · Post	-26.636***	-26.970***	-3.412***	-2.015***	2.192	-15.943*
	(8.195)	(6.670)	(1.037)	(0.696)	(41.348)	(8.146)
Monthly unique visitors	No	Yes	No	Yes	No	No
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Store FE	Yes	Yes	Yes	Yes	Yes	Yes
Dep. var. levels mean in ND, <Aug	164.4	164.4	20.3	20.3	1721.3	361.4
Stores	69	69	660	660	69	660
Observations	828	828	7920	7920	828	7920

Notes: Columns 1–2 restrict the sample to the top 10% of stores with the largest number of Sunday morning visits before the policy change. Columns 3–4 restrict the sample to the remaining stores. Standard errors in parentheses are clustered at the store level. *** Indicates significance at the 1 percent level, ** 5 percent level, * 10 percent level.

Table A.4: Substitution between stores. Logarithm of normalized visits in grocery stores

	Sunday mornings log visits			
	>90th percentile		≤90th percentile	
	(1)	(2)	(3)	(4)
North Dakota · Post	-0.104**	-0.113***	-0.006	-0.001
	(0.052)	(0.042)	(0.048)	(0.040)
Log monthly unique visitors	No	Yes	No	Yes
Month FE	Yes	Yes	Yes	Yes
Store FE	Yes	Yes	Yes	Yes
Dep. var. levels mean in ND, <Aug	2325.6	2325.6	287.3	287.3
Stores	69	69	660	660
Observations	828	828	7920	7920

Notes: Columns 1–2 restrict the sample to the top 10% of stores with the largest number of Sunday morning visits before the policy change. Columns 3–4 restrict the sample to the remaining stores. Standard errors in parentheses are clustered at the store level. *** Indicates significance at the 1 percent level, ** 5 percent level, * 10 percent level.

Table A.5: Substitution across border. Visits and visitors in Walmart stores in Minnesota

	Sunday mornings visits		Monthly unique visitors
	(1)	(2)	(3)
At North Dakota border · Post	-106.706***	-88.482**	-203.466***
	(36.365)	(37.491)	(37.303)
Monthly unique visitors	No	Yes	No
Month FE	Yes	Yes	Yes
Store FE	Yes	Yes	Yes
Dep. var. levels mean at border, <Aug	310.5	310.5	2380.8
Stores	65	65	65
Observations	780	780	780

Notes: Standard errors in parentheses are clustered at the store level. *** Indicates significance at the 1 percent level, ** 5 percent level, * 10 percent level.

Table A.6: Substitution across border. Logarithm of normalized visits in Walmart stores in Minnesota

	Sunday mornings log visits	
	(1)	(2)
At North Dakota border · Post	-0.222**	-0.212**
	(0.108)	(0.085)
Log monthly unique visitors	No	Yes
Month FE	Yes	Yes
Store FE	Yes	Yes
Dep. var. levels mean at border, <Aug	4407.9	4407.9
Stores	65	65
Observations	780	780

Notes: Standard errors in parentheses are clustered at the store level. *** Indicates significance at the 1 percent level, ** 5 percent level, * 10 percent level.

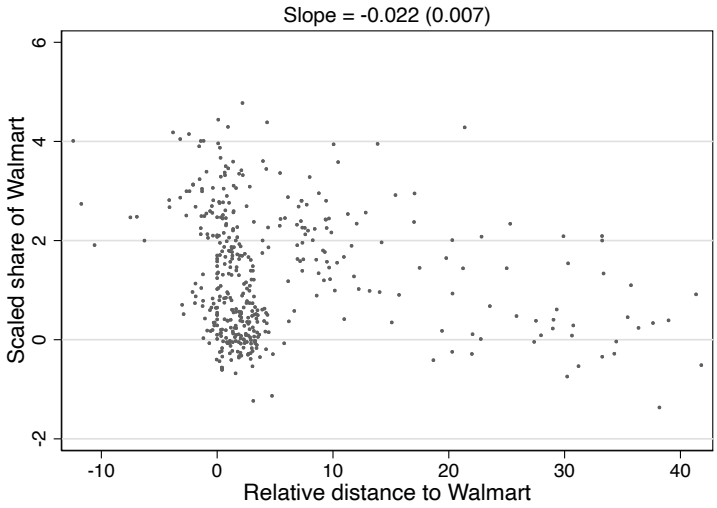


Figure A.1: Relative (to grocery store) distance to Walmart vs logit-transformed market share of Walmart in North Dakota after the change in regulation

Notes: The figure presents a scatter plot, where an observation is a census block group in North Dakota post deregulation. The x-axis measures the distance to the closest Walmart minus the distance to the closest grocery store. The y-axis measures the logit-transformed market share of Walmart $log(s_{iW}/(1-s_{iW}))$, where s_{iW} is the share of Walmart from all grocery and Walmart visits from census block group i. To reduce the noise, we exclude from the sample census block groups in the lowest decile in terms of the average number of devices.

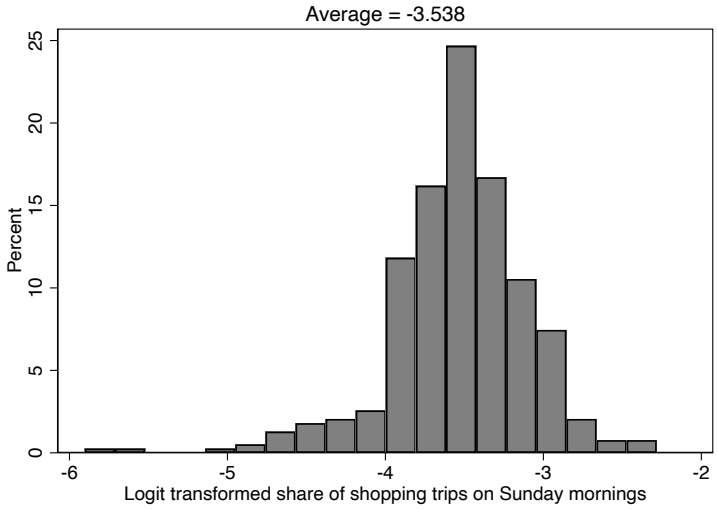


Figure A.2: The distribution of logit transformed share of Sunday morning store visits in North Dakota after the change in regulation

Notes: The figure presents the histogram of the logit transformed share of Sunday morning store visits $\log(s_{jt}/(1-s_{jt}))$, where s_{jt} is the share of visits to store j in month t on Sunday mornings. The sample includes both Walmart stores and grocery stores in weeks post-deregulation.

B Derivations

Using equation (3), we can write the share of consumer i's visit to Walmart as

$$s_{i1} = s_{i10} + s_{i11} = \frac{\exp(\alpha D_{i1} + \gamma)(1 + e^{\beta})}{\sum_{w'=0}^{1} \sum_{t'=0}^{1} \exp(\alpha D_{iw'} + \beta t' + \gamma w')}.$$

The share of the visits to stores other than Walmart is

$$s_{i0} = 1 - s_{i1} = s_{i00} + s_{i01} = \frac{\exp(\alpha D_{i0})(1 + e^{\beta})}{\sum_{w'=0}^{1} \sum_{t'=0}^{1} \exp(\alpha D_{iw'} + \beta t' + \gamma w')}.$$

Taking the difference of the logarithms of these two shares, we get

$$\log \frac{s_{i1}}{1 - s_{i1}} = \log s_{i1} - \log s_{i0} = \gamma + \alpha \Delta_i,$$

where $\Delta_i = D_{i1} - D_{i0}$. This is (6), which we can directly take to the data.

Now, if we fix a store (either Walmart or grocery store) and take a consumer i for whom it is the closest store of the respective type, then the share of this consumer's visits that occur on Sunday is

$$s_{iw1} = \frac{\exp(\alpha D_{iw} + \beta + \gamma w)}{\sum_{w'=0}^{1} \sum_{t'=0}^{1} \exp(\alpha D_{iw'} + \beta t' + \gamma w')}.$$

And the share of visits that occur at all other times is

$$s_{iw0} = \frac{\exp(\alpha D_{iw} + \gamma w)}{\sum_{w'=0}^{1} \sum_{t'=0}^{1} \exp(\alpha D_{iw'} + \beta t' + \gamma w')}.$$

Therefore, the log difference is

$$\log \frac{s_{iw1}}{s_{iw0}} = \log s_{iw1} - \log s_{iw0} = (\alpha D_{iw} + \beta + \gamma w) - (\alpha D_{iw} + \gamma w) = \beta.$$

If we could observe shopping times of each consumer separately, this would be enough to

estimate β. However, in the data, we only observe this information at the store level, i.e., in store j, the share of visits that occurred on Sunday morning vs. other times.

To find this aggregate and see that it does not complicate the analysis, let us introduce some notation. First, let us fix a store j and let its type be $w_j \in \{0, 1\}$. Let the set of consumers for whom it is the closest store of type w_j be denoted by I_j. For each such consumer, let n_i be the number of shopping trips by consumer i.

With this notation, we can compute the total number of shopping trips to the store j that occur at times other than Sunday morning as

$$N_{j0} = \sum_{i \in I_j} n_i s_{iw_j 0} = \sum_{i \in I_j} n_i \frac{\exp(\alpha D_{iw_j} + \gamma w_j)}{\sum_{w'=0}^{1} \sum_{t'=0}^{1} \exp(\alpha D_{iw'} + \beta t' + \gamma w')}.$$

Similarly, we can compute the total number of shopping trips to store j on Sunday morning as

$$\begin{aligned} N_{j1} &= \sum_{i \in I_j} n_i s_{iw_j 1} = \sum_{i \in I_j} n_i \frac{\exp(\alpha D_{iw_j} + \beta + \gamma w_j)}{\sum_{w'=0}^{1} \sum_{t'=0}^{1} \exp(\alpha D_{iw'} + \beta t' + \gamma w')} \\ &= \exp(\beta) \sum_{i \in I_j} n_i \frac{\exp(\alpha D_{iw_j} + \gamma w_j)}{\sum_{w'=0}^{1} \sum_{t'=0}^{1} \exp(\alpha D_{iw'} + \beta t' + \gamma w')} = e^{\beta} N_{j0}. \end{aligned}$$

Therefore, the respective shares are

$$s_{j0} = \frac{N_{j0}}{N_{j0} + N_{j1}} = \frac{1}{1 + e^{\beta}}, \quad s_{j1} = \frac{N_{j1}}{N_{j0} + N_{j1}} = \frac{e^{\beta}}{1 + e^{\beta}}.$$

Computing the log difference gives us

$$\log \frac{s_{j1}}{1 - s_{j1}} = \log s_{j1} - \log s_{j0} = [\beta - \log(1 + e^{\beta})] - [0 - \log(1 + e^{\beta})] = \beta.$$

This is (7).