ECONOMICS OF GUN VIOLENCE[‡]

Measuring the Market for Legal Firearms[†]

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Consumers in the United States value firearms. One-third of households own a firearm, and consumers legally acquire 25 million firearms each year (Miller, Zhang, and Azrael 2022; Moshary, Shapiro, and Drango, forthcoming). At the same time, the firearm market carries potential downstream consequences for public health (Cook 2018). In 2022, there were 48,000 firearm fatalities and at least as many nonfatal firearm injuries (CDC 2023).

A number of public policies to prevent firearm injuries work through firearm markets. These include waiting periods between gun purchase and pickup, licensing regulations on firearm retailers, restrictions on weapon characteristics, and taxes on firearms sales (Smart 2021; Smart et al. 2023; Pear et al. 2023).

With so much oversight on the firearm market, a key first step to understanding how existing regulations work and potentially designing more effective firearm policy is to understand the structure of the market for legal firearms.

In this paper, we document the dynamics and demographic composition of the legal firearm market. To do so, we utilize a publicly accessible administrative dataset from the Firearms Records Bureau (FRB) in Massachusetts. This dataset records all legal firearm transfers in Massachusetts, the date on which each occurs, the acquirer's gender, and their residential zip code.

Our analysis of the dynamics in monthly firearm purchasing yields two broad lessons about measurement in the firearm market. We validate a commonly used proxy for firearm transactions—counts of prepurchase background checks recorded by the National Instant Background Check System (NICS) (Brauer 2013)—by showing a close alignment with verified firearm transactions in Massachusetts. The dynamics of firearm transactions in Massachusetts also closely correlate with the rest of the United States, suggesting that lessons gleaned from administrative data in one state may extrapolate beyond its borders.

To study the composition of firearm demand, we project rates of firearm purchase, as well as the propensity to purchase handguns, onto gender and zip code demographics. Our analysis using zip code demographics yields similar patterns to a nationally representative survey (Parker et al. 2017) with individual-level demographics, whereas an analysis using NICS records and demographics at the state level is less able to detect such patterns. Overall, the high resolution and universal coverage of FRB data within Massachusetts faithfully represents national demographic gradients in firearm demand.

Our analysis complements other approaches to measuring the market for legal firearms. One strand of literature analyzes area-level proxies for firearm ownership or transactions, such as hunting licenses per capita, the circulation of firearm-related media, the share of suicides committed with a firearm, and state-year records from NICS (Schell et al. 2020). These proxies provide excellent coverage across the United States but tend to have low resolution and may be subject to proxy error.

At the other extreme, a number of studies rely on surveys to capture attitudes and behaviors in the firearm market (Parker et al. 2017; Miller, Zhang, and Azrael 2022; Moshary,

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Shapiro, and Drango, forthcoming). Surveys allow for finely tailored measurement, providing a high-resolution view of firearm consumers. However, our analysis shows that surveys may struggle to estimate more nuanced features of the firearm market due to a drop in precision when restricting within a subpopulation. In addition, these surveys typically capture a single cross-section of consumers, rendering it difficult to study trends in the firearm market over time.

The greatest limitation of our analysis also follows from the unique administrative nature of our data. Most of the United States either does not collect or share administrative records of firearm transfers. Studdert et al. (2017) and Iwama and McDevitt (2021) use similar but restricted access administrative data to study the firearm market's response to mass shooting events. Although an extrapolation from settings with administrative data to the rest of the United States can never be fully verified, our analysis suggests that the FRB dataset is a promising, publicly accessible resource to study the consumer firearm market

I. Data

A. *FRB Firearms Transactions*

We measure firearm transactions using the Massachusetts FRB repository of firearm dealer transaction records. For each attempted firearm purchase, Massachusetts law requires an electronic verification of the consumer's firearm license. Our dataset records each successful verification check from firearm dealers, thus capturing the universe of legal firearm transactions at retailers in Massachusetts. To comply with state and federal laws, transactions at gun shows and online marketplaces, respectively, are fully represented in FRB data.

Each FRB record contains detailed information about the firearm as manually entered by the retailer. This information includes the firearm's brand, model, and physical characteristics (e.g., caliber). The FRB data also provide information about the transaction itself. This includes the buyer's gender and the zip code in which they reside according to their firearm license. On the seller's side, the data include the retailer's name, Federal Firearms Listings (FFL) number, and zip code. Finally, FRB records include the transaction date.

Although detailed, the FRB dataset is not representative of the national firearm market. Massachusetts has among the strictest firearm regulations and the lowest rates of firearm ownership in the United States (Schell et al. 2020). Demographically, Massachusetts is more educated, higher income, and more likely to vote Democratic relative the rest of the United States, though it has a similar racial composition.[1]

The FRB data are also silent about the smaller but important market for illegal firearms (Cook 2018).

Our analysis focuses on the retail market for firearms, as documented in the FRB's dealer transaction records. Massachusetts began collecting these data in 2006 and published their records online following a series of Freedom of Information Act requests by Johnson et al. (2023).[2] We restrict our analysis to data from the years 2010–2022. The FRB also maintains a dataset on the smaller number of peer-to-peer firearm transfers, which we do not analyze.

B. *National Firearms Market*

We compare the FRB data, which only cover Massachusetts, to national sources of information about the firearm market.

To study firearm purchasing in other states, we follow the literature and use state-year counts of NICS records.[3] Brauer (2013) notes that NICS records are unlikely to perfectly correspond with firearm transfers, and we follow his methodology for predicting firearm transfers from NICS. Due to differences in NICS implementations across states, our state-level analyses exclude Hawaii, Nebraska, and Iowa, which do not conduct background checks on certain transactions. We treat Washington, DC, as its own state. Overall, this dataset maintains broad coverage over geographies and time but is relatively noisy owing to its low resolution and modest sample size.

We also utilize Wave 26 of the American Trends Panel (ATP), conducted by Pew Research in March and April 2017, to compare the FRB data to nationally representative microdata on

[1] Calculation available in replication archive.

[2] These data are available at https://www.mass.gov/info-details/data-about-firearms-licensing-and-transactions/.

[3] Downloaded from https://github.com/BuzzFeedNews/nics-firearm-background-checks.

firearm consumers.[4] We analyze 3,919 responses to a question about individual firearm ownership and 1,247 responses to questions about the types of firearms each owner possessed, conditional on owning a firearm. We pair these responses with self-reported information on gender, race, political leaning, education level, and income. This dataset provides high-resolution characteristics of firearm consumers but is limited to a single point in time.

C. *Demographic Data*

We complement the FRB dataset with auxiliary data on consumer demographics based on the neighborhood (zip code) in which consumers reside. This includes the distribution of gender, age, race, education, and poverty by zip code from the 2015–2019 five-year American Community Survey (ACS).[5]

Our demographic data also include a measure of local political ideology using voting returns from the 2016 US presidential election.[6] We construct each precinct's conservative vote share and aggregate to the zip code level using the supplied Voting and Elections Science Team (VEST) precinct shapefiles along with US census Topologically Integrated Geographic Encoding and Referencing (TIGER) Zip Code Tabulation Area (ZCTA) shapefiles, weighting precincts by total number of votes.[7]

II. Dynamics of the Firearm Market

Figure 1 compares firearm purchasing rates per 1,000 adults in Massachusetts as observed in the FRB and predicted from NICS. The two Massachusetts series lie essentially on top of one other (Pearson's $\rho = 0.996$), demonstrating that adjusted NICS counts are an excellent proxy for firearm transactions conducted by retailers, at least within Massachusetts from 2010–2022. This close match validates NICS records as a proxy for
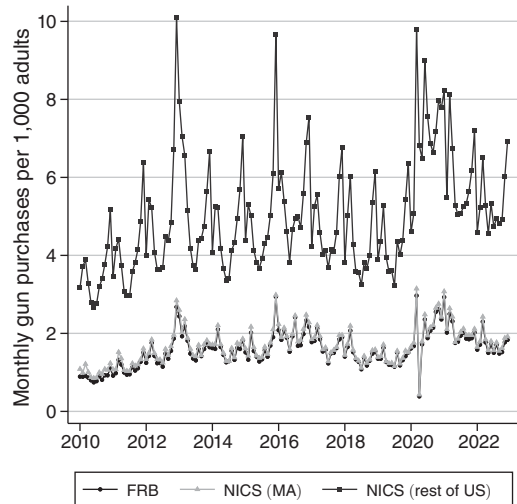

Figure 1. Firearm Purchase Rates in Massachusetts and the United States over Time

Notes: Figure shows monthly firearm purchases per 1,000 adults. Purchases in Massachusetts are computed from either FRB data or NICS. Purchases for the rest of the United States are computed from NICS only.

firearm transactions. This near-perfect match in aggregate trends across the NICS and FRB data also holds when disaggregating firearm transactions by handgun ($\rho = 0.995$) and long gun ($\rho = 0.986$), the most granular weapon information available in NICS.[8]

We also compare firearm purchasing per capita in Massachusetts to the rest of the United States. Although the rest of the United States purchases firearms at double the rate of Massachusetts, the two series highly correlate ($\rho = 0.82$). The high correlation suggests that temporal trends in the Massachusetts firearm market may also apply to the rest of the United States.

Our analysis demonstrates several patterns in the dynamics of firearm demand. It validates industry and journalistic reports of a "Trump Slump" in firearm purchasing.[9] Figure 1 shows that from President Donald Trump's election in late 2016 to the middle of 2019, firearm purchasing deceased by around 20 percent. Starting

[6]Precinct vote shares downloaded from Voting and Elections Science Team (2018) at https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/NH5S2I.

[7]Conservative candidates included Donald Trump (Republican), Gary Johnson (Libertarian), Evan McMullin (Independent), and Darrell Castle (Constitution).

[8]Comparison available in replication archive.

[9]See https://www.nytimes.com/2020/02/23/business/media/guns-sales-advertising-strategy.html.

in 2019, firearm purchasing began to increase each month, before spiking with the onset of the COVID-19 pandemic in March 2020. Surveys of firearm owners during the pandemic capture some of this trend (e.g., Miller, Zhang, and Azrael 2022) but lack the time dimension to fully trace its dynamics.

III. Demographics of Firearm Demand

In this section, we describe the demographic correlates of firearm demand. We show what researchers may be able to learn about the character of firearm demand from administrative data, NICS records, and consumer surveys. Our analysis considers both the extensive margin of firearm purchase and the intensive margin of which firearm buyers choose, conditional on purchase.

A. *Methodology*

To correlate firearm purchase rates with consumer demographics in FRB and NICS data, we calculate total firearm transactions within a demographic cell d. We include firearm transactions from 2015–2019 to match the time period during which the ACS demographics data were collected. We then estimate regressions of the following form:

$$(1) \qquad Y_d = \beta D_d + \varepsilon_d,$$

where D_d denotes cell-level demographics. For the FRB, d denotes zip code $\times$ gender, our most granular measure of consumer demographics. If a cell contain no data, we infer zero purchases, since the FRB data contain all legal transactions in the state. As predictors in FRB data, we include in D a dummy variable for being female, the fraction of conservative voters, the fraction White, the fraction with at least a bachelor's degree, and the fraction below 125 percent of the poverty line. For NICS data, we use state-level demographics. Since NICS does not record the acquirer's gender, we instead include the state's gender ratio as a predictor. All demographics in both datasets are normalized so that zero is the national mean of each dimension.

For the FRB and NICS data, to study behavior on the extensive margin, we use as our dependent variable Y_d the monthly rate of firearm purchases

Table 1—Gun Purchase Frequencies

| | Purchases/1,000 adults | | Own gun |
	MA zips (1)	US states (2)	Survey (3)
Female	−4.856 (0.376)	−123.499 (27.499)	−0.207 (0.014)
White	7.901 (1.179)	7.263 (1.974)	0.064 (0.017)
Conservative	−1.016 (2.157)	4.151 (4.469)	0.221 (0.015)
BA+	−4.278 (1.380)	0.618 (6.866)	−0.123 (0.015)
Poverty	−0.439 (3.177)	25.698 (9.708)	−0.121 (0.021)
Constant	1.985 (0.243)	5.199 (0.268)	0.359 (0.019)
Observations	1,047	48	3,919
R^2	0.18	0.67	0.15

Notes: Table shows regression of firearm acquisition on consumer demographics. Column 1 uses purchases and demographics from zip-gender cells in Massachusetts. Column 2 uses purchases and demographics of US states. Column 3 uses individual gun ownership and demographics from a nationally representative survey. Robust standard errors in parentheses.

per 1,000 adults. To study demographic correlates on the intensive margin of firearm composition, we use the share of firearm purchases that are handguns, dropping observations with zero sales in which this ratio is undefined.

Our analysis of survey data uses individual-level observations of all variables. Dependent variables are indicators for the ownership of any firearm and for the ownership of a handgun, conditional on owning at least one firearm. Predictors are self-reported gender, race, political leaning, education, and poverty status.[10]

For inference, all of our standard errors adjust for heteroskedasticity but assume independence between observations.

B. *Results*

Table 1 presents the demographic correlates of firearm purchase. The FRB data in Column 1

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[10] Since the ATP survey does not ask about poverty status, we instead use a dummy variable for household income below $20,000, which sets a similar proportion of the population's poverty status as low income.

reveal that demographics matter for gun purchase decisions. Firearm purchasing is statistically higher among men and in Whiter areas with less education. These patterns explain 18 percent of the variation in firearm purchasing across neighborhoods.

The demographic gradients within Massachusetts—and their overall predictive accuracy—broadly match the demographics of firearm ownership from surveys in column 3. The one exception is conservative political leaning, the single strongest predictor of firearm purchase in the survey data, which is not statistically significant in the FRB data.[11] The close match between FRB and national survey data suggests that demographic gradients in firearm demand within Massachusetts likely extrapolate to the rest of the United States. Our finding may follow from the high levels of residential segregation in the United States, such that neighborhood socioeconomic demographics are reasonable proxies for individual-level characteristics (Reardon, Fox, and Townsend 2015).

In contrast, column 2 shows that demographic patterns in firearm acquisitions are measured with less precision when using state-level NICS records. Moreover, the point estimate on poverty is wrong signed and highly significant, incorrectly suggesting that gun purchasing decreases with income. Perhaps unsurprisingly, given that state dummies only explain 10–30 percent of the variation in neighborhood demographics, the aggregated NICS data are less equipped to detect demographic patterns in firearm purchase.[12]

Table 2 considers demographic correlates of firearm choice of a handgun or long gun, conditional on the purchase of a firearm. Column 1 shows that the handgun share is higher among women and those in conservative, racially diverse, and more educated areas. Using only state-level NICS data in column 2 would reveal no information about these demographic gradients.

In column 3, survey data produce similar but less precise estimates of these demographic

Table 2—Handgun Purchase Share

	Share handgun		Own handgun
	MA zips (1)	US states (2)	Survey (3)
Female	0.166 (0.007)	1.771 (1.183)	0.057 (0.024)
White	−0.303 (0.031)	−0.041 (0.098)	−0.114 (0.031)
Conservative	0.170 (0.046)	−0.091 (0.152)	0.118 (0.027)
BA+	0.096 (0.035)	0.627 (0.407)	−0.024 (0.024)
Poverty	−0.009 (0.087)	0.777 (0.588)	−0.068 (0.046)
Constant	0.749 (0.007)	0.563 (0.021)	0.793 (0.033)
Observations	1,041	48	1,247
R^2	0.42	0.28	0.03

Notes: Table shows regression of handgun acquisition shares on consumer demographics. Column 1 uses purchases and demographics from zip-gender cells in Massachusetts. Column 2 uses purchases and demographics of US states. Column 3 uses individual-level indicators for handgun ownership and demographics among owners of any firearm from a nationally representative survey. Robust standard errors in parentheses.

patterns. Surveys may struggle with power when analyzing the compositional component of firearm choice since conditioning on firearm ownership decreases sample size by 60 percent. In contrast, the FRB data capture the universe of firearm transactions in Massachusetts, ensuring that patterns on the extensive and intensive margins of firearm demand are estimated with similar precision.

IV. Conclusion

In this paper, we describe and analyze a dataset that covers the universe of legal firearm transactions in Massachusetts. We use this dataset to validate a common proxy for firearm transactions, demonstrate similarity between the Massachusetts and US firearm markets, and reinforce evidence on the recent dynamics of firearm purchasing. We also document demographic gradients in firearm demand across neighborhoods that closely replicate individual-level demographic data.

We conclude that these high-resolution transaction data offer a valuable source of information

[11] This is attributable to the high positive (negative) correlation of conservativeness with fraction White (fraction with BA+) across zip codes. When we exclude either of these demographics from the regression, the coefficient on conservative for the FRB data is positive and statistically significant.

[12] Calculation available in replication archive.

about firearm markets. As these transaction data increasingly become used by researchers, we expect to learn more about the market for legal firearms.

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