State Firearm Laws and Interstate Transfer of Guns in the USA, 2006–2016

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Abstract In a cross-sectional, panel study, we examined the relationship between state firearm laws and the extent of interstate transfer of guns, as measured by the percentage of crime guns recovered in a state and traced to an in-state source (as opposed to guns recovered in a state and traced to an out-of-state source). We used 2006–2016 data on state firearm laws obtained from a search of selected state statutes and 2006–2016 crime gun trace data from the Bureau of Alcohol, Tobacco, Firearms, and Explosives. We examined the relationship between state firearm laws and interstate transfer of guns using annual data from all 50 states during the period 2006–2016 and employing a two-way fixed effects model. The primary outcome variable was the percentage of crime guns recovered in a state that could be traced to an original point of purchase within that state as opposed to another state. The main exposure variables were eight specific state

firearm laws pertaining to dealer licensing, sales restrictions, background checks, registration, prohibitors for firearm purchase, and straw purchase of guns. Four laws were independently associated with a significantly lower percentage of in-state guns: a waiting period for handgun purchase, permits required for firearm purchase, prohibition of firearm possession by people convicted of a violent misdemeanor, and a requirement for relinquishment of firearms when a person becomes disqualified from owning them. States with a higher number of gun laws had a lower percentage of traced guns to in-state dealers, with each increase of one in the total number of laws associated with a decrease of 1.6 percentage points in the proportion of recovered guns that were traced to an in-state as opposed to an out-of-state source. Based on an examination of the movement patterns of guns across states, the overall observed pattern of gun flow was out of states with weak gun laws and into states with strong gun laws. These findings indicate that certain state firearm laws are associated with a lower percentage of recovered crime guns being traced to an in-state source, suggesting reduced access to guns in states with those laws.

Keywords Firearms · Laws · Gun trafficking · Violence

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Although it has been established that the state-level availability of firearms is positively associated with homicide rates in the USA [1], much less is known about which state-level firearm laws may reduce the availability of weapons. Most studies of the impact of

state firearm laws have focused on long-term outcomes, particularly homicide rates, which have multiple determinants and are thus difficult to study. Several studies, however, have examined a less distal outcome, investigating whether state gun laws have an immediate effect on how easy it is to obtain firearms in that state. The ease of obtaining firearms is assessed by recovering guns used in crimes in a state and tracing these guns back to their original point of purchase [2]. The underlying hypothesis is that if state gun laws are effective, it should be more difficult to obtain a firearm in states with those laws, and thus the percentage of traced crime guns with an out-of-state origin will be higher [2].

The Bureau of Alcohol, Tobacco, Firearms, and Explosives (ATF) maintains a database of records on guns used in crime which are successfully traced to their original point of purchase [3]. When a crime is committed with a firearm and that firearm is recovered, local police departments may request that ATF conduct a trace to determine the original purchase point of the gun. The state origin of the gun and the state where the gun was recovered are recorded. By analyzing these records for each of the 50 states, one can determine what percentage of recovered, traced guns originated in-state versus out-of-state.

Several prior studies have used crime gun trace data to assess the impact of state gun laws on access to firearms, as measured by the extent of recovery of out-of-state guns [4–11]. In a 1996 study, Weil and Knox demonstrated that Virginia's one gun per month law, which limited sales of firearms to one to any individual adult within a 30-day period, resulted in fewer guns being purchased in Virginia and later used in crimes in Northeast states during the period 1990–1994 [4]. Similarly, in a 2001 study of all US states, Webster et al. found that laws that both require individuals to have a license to purchase a gun and mandate that guns be registered were associated with a substantially lower percentage of guns traced to gun dealers in those states [5]. In a 2009 study, Webster et al. reported that several state laws regulating gun dealers and gun sales were associated with lower rates of recovery of guns that were originally purchased at retail less than one year before their recovery in a crime, which they used as an indicator of guns that were likely to have been obtained illegally [6]. In a 2010 report, Mayors Against Illegal Guns demonstrated that several state gun sales and possession laws were each associated with a lower percentage of guns originating in that state and

recovered after a crime in another state in 2009 [7]. In a 2011 report, Knight used crime gun trace data to show that firearms tended to flow from states with weak gun laws to those with stronger gun laws [8]. In 2013, Webster et al. reported that state laws that require permits to purchase guns, require background checks for all gun sales, and require reporting of the loss or theft of a firearm by private gun owners were each associated with lower rates of guns being purchased in that state and recovered after a crime in another state [9]. A 2016 study by New York's Office of the Attorney General reported a correlation between the presence of a state law requiring permits for gun purchase or mandating background checks for all gun sales and a decreased likelihood of guns from that state being recovered in crimes committed in New York State between 2010 and 2015 [10].

Because many of the state laws that regulate the purchase of firearms were enacted in the past five years (following the Sandy Hook tragedy), the results of very recent studies are particularly important. Three studies published in 2017 related the percentage of traced guns originally purchased in-state to the strength of state gun legislation. Collins et al. reported that the percentage of traced crime guns recovered in-state was substantially lower for Chicago and Prince George's County, Maryland—states with strong gun laws—than for New Orleans, a city located in a state with lax gun laws [11]. Like Weil and Knox, Braga found that implementation of Virginia's one gun per month law was associated with a decline in guns recovered in Massachusetts that were traced to Virginia [12]. Crifasi et al. demonstrated that the implementation of Maryland's Firearm Safety Act of 2013, which required a license to purchase a handgun, mandated reporting of lost or stolen firearms, and increased the authority of state police to sanction licensed gun dealers who do not comply with state firearms sales regulations, was associated with a 20% increase in the proportion of Baltimore crime guns traced to an out-of-state source, although the increase was not statistically significant [13]. Coates and Pearson-Merkowitz reported in a 2017 article that states with stronger firearm laws had a higher percentage of traced crime guns that were recovered out-of-state during the period 2007–2013 [14].

The major limitation of the existing research is that most prior studies have used data that spans only a few years, most focus on earlier time periods (such as the late 1990s and 2000s), and some analyses were

conducted with data from only one state or a handful of cities. Only one previous study [14] used data from all 50 states and included data for more than three years.

Another important limitation of most prior research is that it is unclear whether changes in state gun laws over time are associated with changes in the source of crime guns (“within effects”) or whether the results simply reflect cross-sectional variation between states (“between effects”). The finding of temporal effects is critical because it builds a stronger case for causal inference.

In this paper, we investigate the relationship between state firearm laws and interstate transfer of guns using crime gun trace data for all 50 states that spans a full decade (2006–2016), making this the most comprehensive study on this topic to date. We build upon previous work by using a two-way fixed effects model (i.e., fixed effects for state and year), adding an additional three years to the analysis, adding controls for state-level gun ownership and production, and using a database of state firearm laws that is more detailed than has been used previously. We also study both specific laws and an index of the overall strength of a state’s gun laws.

Methods

Design Overview

We examined the relationship between state firearm laws and interstate transfer of guns in a panel study using annual data from all 50 states during the 10-year period 2006–2016. The primary outcome variable was the percentage of crime guns recovered in one state and traced to an original point of purchase within that state as opposed to another state. The main exposure variables were a set of eight state firearm laws that pertain to dealer licensing, waiting periods, licensing and permitting, prohibitors for gun purchase, background checks, and straw purchase of guns. Using a linear regression with state and year fixed effects, we modeled the relationship between the state gun laws and the percentage of crime guns recovered in that state, while controlling for several state-level factors and employing robust standard errors that account for serial correlation and clustering of the data at the state level.

Data Sources and Measures

Outcome Variables

Data on crime gun traces were obtained from the Bureau of Alcohol, Tobacco, Firearms, and Explosives (ATF) for the period 2006–2016 [3]. Using these data, we calculated (1) the number and percentage of crime guns originating in each state but that were used in a crime in another state (i.e., “exports”); and (2) the number and percentage of crime guns originating in other states that were used for crimes in that state (i.e., “imports”). In other words, for a given state, we refer to guns recovered in that state which originated from other states as “imports,” and guns recovered in other states but originated from that state as “exports.” The main outcome measure used in our analysis was the percentage of crime guns recovered in a state and traced to an in-state vs. an out-of-state source (subsequently referred to as the “percentage of in-state guns”). In prior research, a lower percentage of in-state guns is one widely used indicator of a higher level of interstate transfer of guns into that state (“imports”).

The ATF has made crime gun trace data publicly available for the years 2006–2016 [3]. For the more recent years (2010–2016), the ATF provides on its website spreadsheets with the total counts of all firearms recovered in each state and their source state. Using these data, the percentage of in-state guns can be calculated as the ratio of guns traced to in-state dealers divided by the total number of guns successfully traced. For earlier years (2006–2009), the ATF does not provide spreadsheets but instead provides maps for each state showing the origin of traced guns for the top 15 states supplying guns to that state. An estimate of the percentage of in-state guns was derived by re-creating an import-export spreadsheet using data from all 50 state maps to count the number of firearms recovered in each state and their source state. Because the number of traced guns is shown only for the top 15 states supplying guns to a state, there is a small proportion of traced guns whose state of origin is not reported. Although not all traced guns are included in the 2006–2009 data because the destination of guns from states with small numbers of exports are not provided by ATF, estimates of the percentage of in-state guns from the 2006–2009 data are highly correlated with estimates derived from the more recent data ($r = 0.93$).

Exposure Variables

We created a state firearm law database that tracks 133 different gun law provisions covering 14 categories of laws across all 50 states for each year during the study period, 2006–2016 (www.statefirearmlaws.org) [15]. The database was created by analyzing each state's laws annually using Thomson Reuters Westlaw [16] and coding each of the provisions. The methods are described in detail elsewhere [15]. The unique aspect of this database is that it includes detailed definitions of each state law provision, including the specific exemptions that are or are not allowed in order to code the state as having that provision. For this study, we selected eight provisions from the database which might be expected to affect the ease of obtaining a gun. These provisions related to dealer licensing, gun registration and recordkeeping, sales permits, waiting periods, prohibitors for gun purchase, background checks, and prohibition of straw purchases or purchase of a firearm with the intent to sell to someone else.

The specific laws were as follows: (1) a state license is required for all firearm dealers; (2) a waiting period is required before the sale of a handgun; (3) a permit is required to purchase a firearm; (4) handguns must be registered or records must be kept of every handgun sale; (5) people with a history of a violent misdemeanor are not allowed to purchase firearms; (6) people who become prohibited from possessing a firearm must relinquish all guns in their possession; (7) all firearm purchases require a background check; and (8) straw purchase of a firearm is a state criminal offense. The complete list of provisions is shown in Table 1. We also derived a “gun law index” for each state by summing the number of these provisions present in a state during a given year. Thus, the scale was from 0 to 8. Our main analysis examined the effect of each of these laws simultaneously. A secondary analysis examined the gun law index as the exposure variable.

Control Variables

We controlled for the following seven time-varying, state-level factors: (1) household gun ownership, measured using a widely used proxy (the percentage of suicides committed using a firearm [FS/S]) [17]; (2) state population (in millions); (3) immigration rate, defined as the number of people greater than one year old with a different state of residence during the prior year

divided by the current population greater than one year old, derived from the American Community Survey [18]; (4) the per capita gun production for domestic use in the state, derived from the ATF's Annual Firearms Manufacturers and Export Report (in guns manufactured per resident) [19]; (5) the per capita number of federally licensed gun dealers (FFLs), in dealers per 100,000 population, obtained from data provided by the ATF [20]; (6) the rate of property crime (burglary, larceny-theft, and motor vehicle theft) per 100,000 population, obtained from the FBI Uniform Crime Reports [21]; and (7) the percentage of the population living in urban areas, derived from the U.S. Census Bureau [22].

Data Analysis

We first examined the general interstate flow of crime guns by comparing the gun law indices in each state with those in two other states: (1) the state that was the primary out-of-state destination for guns traced from the state in question (the “destination state” index); and (2) the gun law index for the state that was the primary out-of-state source for guns recovered in the state in question (the “source state” index). If stronger state firearm laws make it more difficult to obtain a gun, then guns should generally flow from states with weaker laws to those with stronger laws. Thus, the gun law index in each primary destination state should be higher than that in each source state. We tested this hypothesis by comparing the gun law indices in the primary source states with those in the primary destination states.

We then modeled the continuous outcome variable using linear regression with year and state fixed effects. We used robust standard errors that account for the clustering of observations, serial autocorrelation, and heteroscedasticity [23]. All analyses were conducted using the xtreg procedure in STATA version 14 (College Station, TX: The Stata Corporation).

Because of the inclusion of multiple state law variables that could be correlated, we conducted two tests to detect potential problems with multicollinearity. First, we compared the regression coefficients for each law variable with coefficients obtained from a model that only included that law alone (excluding the other laws). The similarity of results across these two models suggests that collinearity is not a problem. Second, we computed variance inflation factors for each law variable.

Table 1 State firearm laws analyzed

	Sub-category	Brief description of provision	Detailed description of provision	Number of states with law, 2006	Number of states with law, 2016
Dealer regulation	Licensing	State dealer license required for handgun sales	All dealers which sell handguns must have a state license	16	14
Buyer regulation	Waiting period	Waiting period is required on all handgun purchases from dealers	There is a mandatory minimum waiting period for purchase of a handgun from a dealer (no exemption for concealed carry or purchase permit holders)	9	8
Buyer regulation	Licensing	A license or permit is required to purchase all firearms	Firearms may only be sold to and/or possessed by individuals who have a valid license or permit. Requirement for license to possess or carry firearms is OK. Requirement for a firearm safety certificate is OK. Must apply to all sellers.	5	7
Gun registration and sales records	Registration/ recordkeeping	Registration of handguns is required or de facto registration of handguns is in place because of a recordkeeping requirement for all handgun sales	All purchased handguns are registered with the state because of a requirement that all gun sales involve the permanent or indefinite retention of a record including the manufacturer, make, model, and serial number of the firearm; or, there is registration of all handguns.	8	9
Prohibitors for high-risk gun possession	Prohibitors—violent misdemeanor	Firearm possession is prohibited for people with a history of a violent misdemeanor punishable by less than one year of imprisonment	Law prohibits firearm possession by people who have committed violent misdemeanors punishable by less than one year of imprisonment.	3	5
Prohibitions for high-risk gun possession	Relinquishment of weapons	People are required to relinquish their firearms after they become prohibited from possessing them	Law requires that upon becoming prohibited from possessing a firearm, a person must relinquish all firearms in their possession. This must be a broad provision that covers most, if not all, categories of prohibited people. For example, if the law only applies to mental health prohibitors, it is not considered to satisfy the requirements for having this provision. The law must explicitly require the relinquishment of weapons, not	4	6

Table 1 (continued)

Sub-category	Brief description of provision	Detailed description of provision	Number of states with law, 2006	Number of states with law, 2016
Background checks	Universal background checks	Background checks conducted through permit requirement for all firearm sales (or universal background checks)	7	12
Illegal purchase/transfer of handguns	Straw purchase	<p>merely prohibit the possession of weapons.</p> <p>Individuals must undergo a background check to purchase any type of firearm, either at the point of purchase or through a license/permit application. This may or may not include exemptions for buyers who have already undergone a background check for a concealed carry permit or other licensing requirements.</p> <p>The law prohibits a straw purchase of handguns; that is, no person may purchase a handgun on behalf of another person. An exemption for transfer to relatives is acceptable.</p>	3	4

Results

The average gun law index during the study period ranged from 0 in 24 states to 6.1 in Hawaii and California (Table 2). The average percentage of traced in-state guns ranged from a low of 22.8% in New Jersey (with an average gun law index of 5.0) to a high of 83.8% in Indiana (with an average gun law index of 1.0). There was a strong negative correlation between the average gun law index and the proportion of crime guns recovered in a state and traced to an in-state source ($r = -0.62$, $p < 0.0001$) (Figs. 1 and 2). The proportion of in-state guns was relatively stable over time, despite the different methodology used for 2006–2009 vs. 2010–2016 estimates; in particular, there was no appreciable change in the percentage of in-state guns from 2009 to 2010 (Fig. 3).

Between 2006 and 2016, ten states adopted one or more of the eight firearm laws that were examined in this study (Table 3). The mean change from 2006 to 2016 in the percentage of in-state guns among the three states that enacted two new laws was a decrease of 6.7%, compared to a decrease of 0.8% in states that adopted one law and an increase of 4.5% in states that failed to enact any new laws or that repealed a law (Fig. 4).

Based on an examination of the primary export destination and import source states, the general pattern of gun flow was from states with weak gun laws to those with strong gun laws: (1) from Southeastern states with weak gun laws up the coast to Maryland, New York, and Massachusetts; (2) from Midwestern states with weak gun laws to Illinois; and (3) from Western states with weak gun laws to California (Table 4). While the average gun law index across the primary destination states was 3.3, the average gun law index for the primary source states was 1.4.

In linear regression analyses, we found that the overall gun law index was negatively associated with the proportion of in-state guns, with each increase of one in the gun law index associated with a decrease of 1.56 percentage points in the proportion of in-state guns (95% confidence interval [CI], -3.06 to -0.06) (Table 5). Four laws were independently associated with a significantly lower percentage of in-state guns: a waiting period for handgun purchase, permits required for firearm purchase, prohibition of firearm possession by people convicted of a violent misdemeanor, and a requirement for relinquishment of firearms when a

Table 2 Average gun law index and percent of in-state guns, 2006–2016

State	Gun law index ^a (average 2006–2016)	Percent in-state guns (average 2006–2016)
Alaska	0.0	81.8
Vermont	0.0	64.4
Arizona	0.0	79.9
Wyoming	0.0	56.5
Maine	0.0	75.8
Mississippi	0.0	76.2
Idaho	0.0	62.3
Kansas	0.0	68.7
Arkansas	0.0	71.6
Kentucky	0.0	73.9
Louisiana	0.0	80.6
Montana	0.0	66.8
New Mexico	0.0	72.6
Oklahoma	0.0	75.3
South Dakota	0.0	64.2
Texas	0.0	82.0
Missouri	0.0	68.2
West Virginia	0.0	68.9
Florida	0.0	78.4
North Dakota	0.0	61.9
Utah	0.0	72.3
Ohio	0.0	79.8
Iowa	0.0	67.7
Nebraska	0.0	66.9
Nevada	0.1	64.0
Oregon	0.1	71.7
Colorado	0.2	67.0
North Carolina	0.2	72.4
Tennessee	0.5	65.6
Virginia	0.5	79.6
Georgia	0.8	77.3
South Carolina	0.8	72.0
Wisconsin	0.9	79.2
New Hampshire	1.0	65.8
Indiana	1.0	83.8
Minnesota	1.0	69.9
Michigan	1.0	67.2
Delaware	1.2	60.6
Alabama	1.3	80.8
Washington	1.4	70.6
Connecticut	2.7	60.1
Illinois	3.2	50.6

Table 2 (continued)

State	Gun law index ^a (average 2006–2016)	Percent in-state guns (average 2006–2016)
<i>New York</i>	3.4	30.4
<i>Maryland</i>	3.4	56.3
<i>Rhode Island</i>	4.0	57.7
Pennsylvania	4.3	79.4
<i>New Jersey</i>	5.0	22.8
<i>Massachusetts</i>	5.7	37.6
<i>Hawaii</i>	6.1	40.8
California	6.1	71.4
Average of all states	1.1	67.4

Italic presentation indicates states with a percentage of in-state guns of less than 60%

^aWe derived a “gun law index” for each state by summing the number of law provisions present in a state during a given year. The scale is from 0 to 8 and sums eight provisions: (1) a state license is required for all firearm dealers; (2) a waiting period is required before the sale of a handgun; (3) a permit is required to purchase a firearm; (4) handguns must be registered or records must be kept of every handgun sale; (5) people with a history of a violent misdemeanor are not allowed to purchase firearms; (6) people who become prohibited from possessing a firearm must relinquish all guns in their possession; (7) all firearm purchases require a background check; and (8) straw purchase of a firearm is a state criminal offense. The complete list of provisions is shown in Table 1

person becomes disqualified from owning them. The regression coefficients for each of these laws were similar between a model in which all were entered together and models in which each was included one at a time. None of the other laws and none of the control variables were significantly associated with the percentage of in-state guns. The variance inflation factors for all eight of the laws were below four.

Discussion

To the best of our knowledge, this is the first study to use a fixed effects panel model to examine the relationship between changes in state firearm laws and changes in the ease of obtaining firearms in a state, as measured by the percentage of crime guns recovered in that state and traced to an in-state compared to an out-of-state source. Prior studies have demonstrated a cross-sectional relationship between the percentage of in-state guns and the strength of a state’s firearm laws [4–14]. Here, we show

The study confirms prior research showing that stronger laws reduce the availability of in-state guns involved

Key
Average Percent In-State Guns,
2006-2016

- <50%
- >50-65%
- >65%-75%
- >75%

*Each state is labeled with its
average number of gun laws,
2006-2016*

State	Average Number of Gun Laws (2006-2016)	Category
AK	0	>75%
AL	1.3	>75%
AR	0	>65%-75%
AZ	0	>75%
CA	6.1	>65%-75%
CO	0.2	>65%-75%
CT	4	>65%-75%
DE	1.2	>65%-75%
FL	0	>75%
GA	0.8	>75%
HI	6.1	>65%-75%
IA	0	>65%-75%
ID	0	>50-65%
IL	3.2	>50-65%
IN	1	>75%
KS	0	>65%-75%
KY	0	>65%-75%
LA	0	>75%
MA	5.7	>75%
MD	3.4	>65%-75%
ME	0	>75%
MN	1	>65%-75%
MS	0	>75%
MT	0	>65%-75%
NC	0.2	>65%-75%
ND	0	>50-65%
NE	0	>65%-75%
NH	1	>50-65%
NJ	5	>65%-75%
NM	0	>65%-75%
NV	0.1	>50-65%
NY	3.4	>65%-75%
OH	0	>65%-75%
OK	0	>65%-75%
OR	0.1	>65%-75%
PA	4.3	>65%-75%
RI	2.7	>65%-75%
SC	0.8	>65%-75%
SD	0	>50-65%
TN	0.5	>65%-75%
TX	0	>75%
UT	0	>65%-75%
VA	0.5	>75%
VT	0	>50-65%
WA	1.4	>65%-75%
WI	0.9	>75%
WV	0	>75%
WY	0	>50-65%

Fig. 2 Heat map of average percentage in-state guns, 2006–2016 showing average gun law index, 2006–2016

Fig. 3 Average percentage of in-state guns, 2006–2016

reduce the availability of firearms from their own state sources should seek to pass legislation that strengthens

regulations on sales and possession, which are part of the overall state gun law index we examined here.

Table 3 Baseline and final gun law indices and percentage of in-state guns, 2006 and 2016.

State	Gun law index, 2006 ^a	Percent in-state guns, 2006	Gun law index, 2016	Percent in-state guns, 2016	Change in gun law index, 2006–2016	Change in percent in-state guns, 2006–2016
Wisconsin	1	76.1	0	82.7	−1	+ 6.6
South Carolina	1	72.3	0	75.0	−1	+ 2.7
Georgia	1	76.7	0	78.1	−1	+ 1.4
Missouri	0	56.4	0	75.1	0	+ 18.7
Michigan	1	58.7	1	74.0	0	+ 15.3
South Dakota	0	52.2	0	67.1	0	+ 14.9
New Hampshire	1	62.6	1	75.6	0	+ 13.0
Arkansas	0	65.7	0	77.1	0	+ 11.4
Utah	0	67.6	0	77.6	0	+ 10.0
Iowa	0	61.1	0	70.2	0	+ 9.1
Nevada	0	62.1	0	71.1	0	+ 9.0
Wyoming	0	49.7	0	58.3	0	+ 8.6
Montana	0	61.3	0	69.0	0	+ 7.7
Minnesota	1	65.1	1	72.1	0	+ 7.0
Vermont	0	52.1	0	58.8	0	+ 6.7
Ohio	0	75.8	0	81.1	0	+ 5.3
Rhode Island	4	55.7	4	60.9	0	+ 5.2

Table 3 (continued)

State	Gun law index, 2006 ^a	Percent in-state guns, 2006	Gun law index, 2016	Percent in-state guns, 2016	Change in gun law index, 2006–2016	Change in percent in-state guns, 2006–2016
Texas	0	79.5	0	84.2	0	+ 4.7
North Dakota	0	54.5	0	59.1	0	+ 4.6
Kentucky	0	72.4	0	76.9	0	+ 4.5
Mississippi	0	75.3	0	79.1	0	+ 3.8
Hawaii	7	43.3	7	46.9	0	+ 3.6
New Mexico	0	69.2	0	72.8	0	+ 3.6
Tennessee	0	64.0	0	67.5	0	+ 3.5
Idaho	0	62.2	0	65.7	0	+ 3.5
Maine	0	76.0	0	79.1	0	+ 3.1
Kansas	0	66.0	0	69.0	0	+ 3.0
Massachusetts	6	34.3	6	36.5	0	+ 2.2
Virginia	0	79.5	0	81.4	0	+ 1.9
Oklahoma	0	75.7	0	76.7	0	+ 1.0
Alaska	0	82.2	0	82.8	0	+ 0.6
Nebraska	0	64.2	0	64.7	0	+ 0.5
Arizona	0	79.0	0	79.4	0	+ 0.4
Florida	0	78.8	0	78.3	0	− 0.5
North Carolina	0	73.5	0	72.2	0	− 1.3
Louisiana	0	80.8	0	79.0	0	− 1.8
Indiana	1	84.5	1	82.5	0	− 2.0
Alabama	1	82.7	1	80.5	0	− 2.2
New Jersey	5	25.7	5	21.0	0	− 4.7
West Virginia	0	73.1	0	67.0	0	− 6.1
Delaware	1	60.3	2	67.1	1	+ 6.8
Pennsylvania	4	78.4	5	79.8	1	+ 1.4
Oregon	0	70.4	1	70.7	1	+ 0.3
Colorado	0	67.4	1	67.1	1	− 0.3
Illinois	3	51.0	4	48.1	1	− 2.9
California	6	71.5	7	67.0	1	− 4.5
Maryland	4	56.6	5	50.0	1	− 6.6
Washington	1	69.1	3	70.6	2	+ 1.5
New York	3	29.3	5	26.6	2	− 2.7
Connecticut	3	67.2	5	48.2	2	− 19.0
Average of all states	1.1	65.4	1.3	68.4	+ 0.2	+ 3.0

^a We derived a “gun law index” for each state by summing the number of law provisions present in a state during a given year. The scale is from 0 to 8 and sums eight provisions: (1) a state license is required for all firearm dealers; (2) a waiting period is required before the sale of a handgun; (3) a permit is required to purchase a firearm; (4) handguns must be registered or records must be kept of every handgun sale; (5) people with a history of a violent misdemeanor are not allowed to purchase firearms; (6) people who become prohibited from possessing a firearm must relinquish all guns in their possession; (7) all firearm purchases require a background check; and (8) straw purchase of a firearm is a state criminal offense. The complete list of provisions is shown in Table 1

The four state firearm laws that we found to be associated with decreased access to in-state crime guns fit into two categories: (1) laws that add restrictions on

who is eligible to purchase and possess a firearm (i.e., laws which prohibit the purchase of guns by people convicted of a violent misdemeanor and which require

Fig. 4 Change in state firearm laws from 2006 to 2016 plotted against change in the percentage of in-state guns during 2006–2016

relinquishment of guns already owned when a person is convicted); and (2) laws that enable enforcement of the firearm sale and possession restrictions (i.e., laws that require permits to purchase and possess firearms and that impose a waiting period before the sale of a handgun). Together, these laws are intended to keep guns out of the hands of people who are not eligible to possess them, especially those who have a history of violent crime.

Our findings are consistent with those of five previous studies that reported a relationship between laws that require a permit to purchase firearms and lower recovery of crime guns with an in-state source [5–7, 9, 13]. Our finding that laws prohibiting gun purchase by people with a history of a violent misdemeanor are associated with lower recovery of in-state crime guns is consistent with a report of Mayors Against Illegal Guns, which reported substantially lower crime gun

Table 4 Primary destination and source states and their average gun law indices, 2006–2016.

State	Average gun law index	Primary destination state	Destination state average gun law index	Primary source state	Source state average gun law index
Alabama	1.3	Georgia	0.8	Georgia	0.8
Alaska	0.0	California	6.1	Oregon	0.1
Arizona	0.0	California	6.1	California	6.1
Arkansas	0.0	Illinois	3.2	Texas	0.0
California	6.1	Nevada	0.1	Arizona	0.0
Colorado	0.2	California	6.1	Texas	0.0
Connecticut	2.7	New York	3.4	Florida	0.0
Delaware	1.2	Maryland	3.4	Pennsylvania	4.3
Florida	0.0	New York	3.4	Georgia	0.8
Georgia	0.8	Florida	0.0	Florida	0.0
Hawaii	6.1	California	6.1	California	6.1
Idaho	0.0	California	6.1	Washington	1.4
Illinois	3.2	Missouri	0.0	Indiana	1.0
Indiana	1.0	Illinois	3.2	Kentucky	0.0
Iowa	0.0	Illinois	3.2	Illinois	3.2
Kansas	0.0	Missouri	0.0	Missouri	0.0

Table 4 (continued)

State	Average gun law index	Primary destination state	Destination state average gun law index	Primary source state	Source state average gun law index
Kentucky	0.0	Ohio	0.0	Indiana	1.0
Louisiana	0.0	Texas	0.0	Texas	0.0
Maine	0.0	Massachusetts	5.7	New Hampshire	1.0
Maryland	3.4	Virginia	0.5	Virginia	0.5
Massachusetts	5.7	New York	3.4	New Hampshire	1.0
Michigan	1.0	Illinois	3.2	Ohio	0.0
Minnesota	1.0	Illinois	3.2	Wisconsin	0.9
Mississippi	0.0	Illinois	3.2	Louisiana	0.0
Missouri	0.0	Illinois	3.2	Kansas	0.0
Montana	0.0	California	6.1	California	6.1
Nebraska	0.0	Iowa	0.0	Iowa	0.0
Nevada	0.1	California	6.1	California	6.1
New Hampshire	1.0	Massachusetts	5.7	Maine	0.0
New Jersey	5.0	Pennsylvania	4.3	Pennsylvania	4.3
New Mexico	0.0	California	6.1	Texas	0.0
New York	3.4	Florida	0.0	Virginia	0.5
North Carolina	0.1	New York	3.4	South Carolina	0.8
North Dakota	0.0	Minnesota	1.0	Minnesota	1.0
Ohio	0.0	Michigan	1.0	Kentucky	0.0
Oklahoma	0.0	Texas	0.0	Texas	0.0
Oregon	0.1	California	6.1	Washington	1.4
Pennsylvania	4.3	New York	3.4	Ohio	0.0
Rhode Island	4.0	Massachusetts	5.7	Massachusetts	5.7
South Carolina	0.8	North Carolina	0.1	North Carolina	0.1
South Dakota	0.0	Minnesota	1.0	North Dakota	0.0
Tennessee	0.5	Illinois	3.2	Mississippi	0.0
Texas	0.0	California	6.1	Louisiana	0.0
Utah	0.0	California	6.1	California	6.1
Vermont	0.0	New York	3.4	Massachusetts	5.7
Virginia	0.5	Maryland	3.4	North Carolina	0.1
Washington	1.4	California	6.1	Oregon	0.1
West Virginia	0.0	Maryland	3.4	Ohio	0.0
Wisconsin	0.9	Illinois	3.2	Illinois	3.2
Wyoming	0.0	Colorado	0.2	Montana	0.0
Average—all states	1.1		3.3		1.4

export rates in states with guns that prohibit gun possession by violent misdemeanants [7]. We are not aware of previous studies that have examined waiting periods for handgun purchase or mandatory relinquishment of firearms by persons who become disqualified from possessing them.

The magnitude of the association between a lowered percentage of crime guns traced to an in-state source and waiting period laws (−1.9%), permit laws (−3.9%), relinquishment laws (−3.2%), and violent misdemeanor laws (−4.7%) was substantial. These estimates suggest that a state enacting all four of these laws would

Table 5 Results of fixed effects linear regression analyses (outcome is the percentage of in-state guns)

Independent variable	All laws included Coefficient (95% CI) [<i>p</i> value]	One law at a time Coefficient (95% CI) [<i>p</i> value]	Variance inflation factor
Control variables			
Population (in millions)	− 0.97 (− 2.57, 0.62) [<i>p</i> = 0.23]		
Percent of population in urban areas	− 0.06 (− 1.47, 1.36) [<i>p</i> = 0.94]		
Immigration rate	− 0.50 (− 2.71, 1.71) [<i>p</i> = 0.66]		
Per capita gun production	0.66 (− 3.49, 4.81) [<i>p</i> = 0.76]		
Per capita FFLs (per 100,000 population)	0.07 (− 0.17, 0.31) [<i>p</i> = 0.59]		
Household gun ownership percentage	0.11 (− 0.04, 0.25) [<i>p</i> = 0.15]		
Property crime rate (per 100,000)	0.08 (− 0.26, 0.42) [<i>p</i> = 0.63]		
Gun laws			
Handgun dealer licensing	2.31 (− 1.23, 5.85) [<i>p</i> = 0.20]	2.47 (− 1.34, 6.28) [<i>p</i> = 0.20]	2.19
Waiting period for handgun purchase	− 1.94* (− 3.22, − 0.67) [<i>p</i> = 0.003]	− 2.41* (− 3.79, − 1.03) [<i>p</i> = 0.001]	1.96
Permit required for firearm purchase	− 3.88* (− 6.01, − 1.75) [<i>p</i> < 0.0001]	− 6.12* (− 9.13, − 3.11) [<i>p</i> < 0.0001]	3.37
Handgun registration or sales recordkeeping	0.04 (− 1.15, 1.23) [<i>p</i> = 0.95]	0.20 (− 1.43, 1.83) [<i>p</i> = 0.81]	3.04
Violent misdemeanor prohibition	− 4.68* (− 7.82, − 1.55) [<i>p</i> = 0.003]	− 5.90* (− 10.38, − 1.41) [<i>p</i> = 0.01]	2.00
Relinquishment required when disqualified	− 3.17* (− 4.95, − 1.39) [<i>p</i> < 0.0001]	− 2.89* (− 4.75, − 1.03) [<i>p</i> = 0.002]	1.78
Universal background checks	− 0.38 (− 2.05, 1.29) [<i>p</i> = 0.66]	− 0.65 (− 2.74, 1.44) [<i>p</i> = 0.54]	3.68
Straw purchase of handguns criminalized	− 1.66 (− 3.34, 0.02) [<i>p</i> = 0.052]	− 1.35 (− 3.01, 0.31) [<i>p</i> = 0.11]	2.12
Gun law index	− 1.56* (− 3.06, − 0.06) [<i>p</i> = 0.04]		

CI confidence interval

*Coefficient is significant at the *p* < 0.05 level

experience a 13.7 percentage point decline in the percentage of in-state guns (assuming there is no interaction between these laws). This represents one standard deviation in the overall distribution of the percentage of in-state guns across all 50 states.

It is important to note that a state's ability to control the availability of firearms also depends on the regulations in other states. Out-of-state guns arrive through various pathways and from various source states, but they make up a fair proportion of all guns recovered and traced across the nation. On average, about one third of all firearms recovered in a typical state were traced to out-of-state sources. However, this national average exists within a nationwide policy context that is highly skewed in the direction of relatively less stringent laws. Most states (37) had an average gun law index score from 2006 to 2016 that was below the mean index score (1.1) for that period, indicating weaker than average

scores. Therefore, it is possible that weak gun laws in nearby states may be limiting the effectiveness of the strong laws that exist in a relatively small number of states. In other words, there may be considerable negative externalities imposed on other states by states with less stringent firearm regulations.

Limitations

One issue not easily overcome by existing data is the quality of the outcome variables used here and in other large scale nationwide studies [13]. These outcomes are based on available firearm trace data, which is subject to discretionary decisions by law enforcement agencies. Differences in enforcement (e.g., locations and types of crimes, success in recovering crime guns, and decision to submit crime guns for tracing) might affect our outcome measure.

Collins et al. have estimated that guns are recovered in just under 25% of crimes that involve guns [11]. We are unaware of any data on the proportion of recovered guns that are submitting for tracing. Approximately 61% of guns submitted to the ATF for tracing are successfully traced [7]. However, we do not suspect these decisions to trace guns or the success of traces to be sufficiently correlated with state legislation to invalidate our findings.

Another important limitation of this study is that interstate transfer of guns does not inherently indicate gun trafficking (i.e., the illegal transfer of guns across state lines). It is possible that some of the crime gun movement occurs due to the legal transport of guns when people move or travel across states. However, the finding that the strength of gun laws is related to interstate movement of firearms suggests that legal movement of firearms is not a primary explanation for the appearance of the traced crime guns in states different from where they were purchased. Handguns cannot be legally purchased out-of-state, so the only permanent legal movement of handguns across state lines occurs when a gun owner moves to another state. There is no reason to believe that people make their decisions about where to live based on the strength of a state's gun laws (and to the extent they do, it is unlikely that gun owners would be choosing to move to states with stronger guns laws). There is also no reason to believe that gun owners who move across states are committing a huge proportion of gun-related crimes. In our analysis, we controlled for the possibility that a higher percentage of in-state guns could be attributed to higher rates of population migration into that state by controlling for the immigration rate into each state. This variable was not related to the outcome measure.

Conclusion

Although additional research is needed on the interstate transfer of firearms, the current study adds to the accumulating evidence of the potential role of state laws in reducing the availability of guns.

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