

## UNDERSTANDING THE INTERSTATE EXPORT OF CRIME GUNS: A GRAVITY MODEL APPROACH

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*In 2009, the Bureau of Alcohol, Tobacco, Firearms and Explosives successfully traced over 145,000 guns recovered at crime scenes in the United States. Of these guns, more than 43,000 were originally sold in a different state from which they were recovered. What factors may explain the interstate movement of these crime guns? This article uses the well-known gravity model of international trade to estimate interstate flow of crime guns. Empirical results show that, like trade of goods and services between nations, the traced movement of crime guns between states is proportionate to the economic sizes of trading partners and is inversely proportionate to the distance between them. In addition, the presence of gangs in one or both states tends to increase the flow of crime guns. Finally, differences in state gun laws tend to affect trade flows with crime guns flowing from states with “weak” gun laws to states with “strict” gun laws. (JEL K00, K42)*

### I. INTRODUCTION

In 2009, according to U.S. government statistics, there was a total of 1,318,398 violent crimes committed nationwide, or about 429.4 violent crimes per 100,000 people.<sup>1</sup> Of these violent crimes firearms were used in approximately 67.1% of murders, 42.6% of robberies, and 20.9% of aggravated assaults. In cases where guns are recovered from crime scenes the Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) attempts to trace the gun to determine its origin. According to data from 2009, of the 238,107 guns recovered from crime scenes, the ATF was able to successfully trace 145,321 (61%) of these guns. Based on these traces the ATF was able to determine that 43,254 of these crime guns (30%) were originally sold in a different state from which they were recovered.<sup>2</sup> The top three states which were

net exporters of crime guns (and the number of net exports) were: Virginia (1,573), Indiana (1,351), and Mississippi (1,199). The top three net importers (and number of net imports) were: New York (3,090), Illinois (2,799), and California (2,690). What may explain why some states tend to be net exporters of illegal guns and others net importers? The goal of this article is to offer an answer to that question.

To explain the movement of crime guns across state lines this article borrows the well-known gravity model from the international trade literature and applies it to interstate movement of crime guns. Results from the estimated gravity model show that the typical factors that explain the movement of goods between nations (e.g., market sizes and the distance between them) also explain the movement of traced crime guns between states. The empirical results also show that differences in the presence of gangs among states partly explain the movement of

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1. U.S. Department of Justice/Federal Bureau of Investigation, *Crime in the United States* ([http://www2.fbi.gov/ucr/cius2009/offenses/violent\\_crime/index.html](http://www2.fbi.gov/ucr/cius2009/offenses/violent_crime/index.html). Accessed on May 26, 2011).

2. These figures and subsequent ones regarding crime guns traced by the ATF are taken from a report by Mayors

Against Illegal Guns (2010). The data in their report were supplied by the ATF.

#### ABBREVIATIONS

ATF: Bureau of Alcohol, Tobacco, Firearms and Explosives  
 FFL: Federal Firearms License  
 GCA: Gun Control Act  
 GDP: Gross Domestic Product  
 OLS: Ordinary Least Squares

traced crime guns between states. Finally, the regression results show that differences in state laws affecting gun ownership and sales are important in explaining the movement of traced crime guns across state lines. For example, one of the robust findings is that states with laws that require owners to report lost or stolen guns tend to export fewer illegal guns to other states. This latter result is of particular interest as it demonstrates an externality or “spillover” effect of differential gun control laws on the flow of illegal guns where states with weak gun control laws tend to export guns to states with stricter laws.

The remainder of this article is organized as follows. Section II provides an overview of the market for illegal guns and federal and state gun laws enacted to control the purchase and sale of guns. Section III develops the model used to estimate the movement of crime guns across states. Section IV contains a description of the estimation approach and the empirical results. Section V contains concluding remarks.

## II. GUN LAWS AND SOURCES OF ILLEGAL GUNS

There are an estimated 250 million guns in circulation in the United States.<sup>3</sup> Laws affecting the purchase and sale of firearms are in place at both the federal and state levels.<sup>4</sup> At the federal level one of the most important laws is the 1968 Gun Control Act (GCA) that requires firearms dealers to hold a federal firearms license (FFL) and prohibits certain individuals from purchasing or owning guns (e.g., convicted felons, illegal drug users, illegal aliens, individuals convicted for domestic violence). In addition, the GCA limits the interstate transfer of guns to only those holding an FFL. The next major federal gun law came 25 years later when the Brady Handgun Violence Protection Act was passed by Congress in 1993. This law requires that licensed dealers conduct a background check of potential purchasers to ensure they are eligible to buy a gun.

How do legal guns become illegal guns? Cook et al. (2007) notes that the transmission

of guns to individuals who are prohibited from owning them generally occurs in three ways. First, given the large stock of guns in circulation, theft is a significant source for those who cannot legally purchase them. Cook and Ludwig (1996) estimate that over 500,000 guns are stolen each year. A second source of guns for those prohibited from purchasing them from licensed dealers is the lesser regulated secondary market such as gun shows and individual sales of guns, the former having an estimated volume of 2 to 3 million per year.<sup>5</sup> Third, guns may end up in the hands of criminals if individuals who legally bought guns end up turning to a life of crime.

In addition to the above, the ATF has identified another major source of illegal guns: corrupt licensed dealers. During the period from July 1996 to December 1998 the ATF conducted 1,530 investigations into illegal firearm trafficking. Of the more than 84,000 guns that were illegally trafficked, more than 40,000 had corrupt dealers as the source.<sup>6</sup>

In an effort to reduce the ease with which criminals can obtain guns many states have put into place additional laws that govern the purchase and sale of firearms. In some cases these laws run parallel to those already in place at the federal level. For example, it is a felony under the GCA for an individual to knowingly participate in a “straw” purchase. A straw purchase is where an individual legally obtains a firearm on behalf of someone else who is prohibited from purchasing one. Currently, nine states and Washington DC have laws in place that allow for *local* prosecution and incarceration of individuals participating in straw purchases.<sup>7</sup> In other cases, states have enacted laws that do not have parallel laws at the federal level. For example 16 states and Washington DC require background checks for purchasers at guns shows.<sup>8,9</sup>

In addition to these two examples, a 2010 publication by a group called Mayors Against Illegal Guns identifies eight other state laws that are believed to have had an impact on illegal

5. Cook et al. (2007, p. F561).

6. ATF (2000, Table 3, p. 13).

7. Hawaii, Illinois, Iowa, Maryland, Massachusetts, New Jersey, New York, North Carolina, and Virginia.

8. California, Colorado, Connecticut, Hawaii, Illinois, Iowa, Maryland, Massachusetts, Michigan, Nebraska, New Jersey, New York, North Carolina, Oregon, Pennsylvania, and Rhode Island.

9. Private sellers who are not officially in the business of selling guns and who only occasionally sell them are not required by the GCA to have an FFL and are thus not required by federal law to conduct a background check.

3. Philip J. Cook and Jens Ludwig have written extensively on the issues of gun ownership and policy. Cook and Ludwig (1996, 2006) provide an estimate of between 200 and 250 million guns in circulation in the United States. The authors provide an increased estimate of 250 to 300 million in a 2010 *Washington Post* article (Cook and Ludwig 2010).

4. Much of this discussion draws from Cook et al. (2007). See Vernick and Hepburn (2003) for a detailed discussion on federal and state gun laws.

gun purchases and sales. These additional eight are briefly described below.<sup>10</sup> State laws that parallel federal laws:

- Allowance for *local* prosecution and incarceration of those who provide false information during the purchase of a firearm.
- Allowance for *local* prosecution and incarceration of gun dealers who fail to conduct a proper background check at the time of purchase.

State gun laws without parallel federal laws:

- The requirement that an individual must obtain a state-issued permit to purchase a handgun.
- Laws granting local law enforcement agencies the ability to use discretion over whether to approve or deny an application for a permit to carry a concealed handgun.<sup>11</sup>
- Laws preventing those who have committed violent misdemeanors from legally possessing a gun.<sup>12</sup>
- A requirement that lost or stolen guns be reported to local law enforcement.<sup>13</sup>
- State laws that grant municipalities the right to regulate firearms.
- State laws allowing or requiring state inspections of gun dealers.<sup>14</sup>

As illustrated in Figure 1, there is considerable variation at the state level with regard to these ten gun laws. States on average have three of the above laws in place. Two states, (New York and New Jersey), have all 10 laws in place whereas 12 others (Alaska, Arizona, Idaho, Kansas, Kentucky, Louisiana, Nevada, New Mexico, Oklahoma, South Dakota, Texas, and West Virginia) do not have any of them in

place. One might expect that states with laws that are more restrictive would exhibit different behavior in terms of net flows of illegal guns than states that are less restrictive. This issue of the effects of differential state gun laws on the pattern of illegal gun exports across state lines is taken up in the next section.

### III. MODELING OF INTERSTATE GUN EXPORTS

The article by Cook et al. (2007) provides an interesting glimpse of the underground market for guns. The authors conduct interviews with, "...gang members, gun dealers, professional thieves, prostitutes, police, public security guards and teenagers in the city of Chicago" (p. F558) in order to understand how guns flow in the underground market. They find, among other things, that contrary to popular perception the purchase of underground guns entails significant transactions costs.<sup>15</sup> The authors hypothesize that these transaction costs are, in part, due to the "thinness" and illegality of the market for underground guns. These two factors, market thinness and illegality, suggest possible motivations for the movement of illegal guns across state lines.

Assuming that larger economies are positively associated with larger underground gun markets, then this would mean that larger economies would also tend to have lower transaction costs for purchasing an underground gun as the matching of sellers with prospective buyers would be facilitated in these "thicker" markets. This view is expressed by Cook et al. (2007, p. F569) who, appealing to the matching model of Diamond (1982), write:

*Illegality makes it difficult to advertise, and so trade requires some search effort by both buyers and sellers with some probability of failure that is inversely related to overall market activity. In this type of environment economic activities can create trading externalities and positive feedback effects: "The externality comes from the plausible assumption that an increase in the number of potential trading partners makes trade easier. The positive feedback is that easier trade, in turn, makes production more profitable", (Diamond, 1982, p. 882). That is, there will be a market "thickness" effect where search costs decline with an increase in the number of market participants.*

15. Cook et al. (2007, p. F564) also report that, based on interviews of gun owning, non-gang affiliated youths, the price paid for a gun on the "underground gun market" was between \$250 and \$400.

10. Table A1 in the Appendix provides a listing of which of the ten laws being considered in this article are in place in the 50 U.S. states. Most of the information on state gun laws was taken from Mayors Against Illegal Guns (2010). The ten laws considered in their study were selected by consulting with mayors, other policy makers, and current and former law enforcement officials.

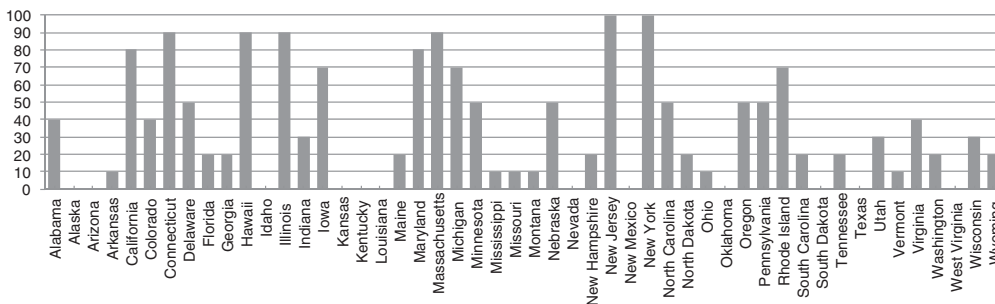
11. While most states require that an individual obtain a permit in order to legally carry a concealed handgun, less than half the states grant local law officials the right to use discretion in deciding whether a permit will be issued.

12. The GCA bans those committing felonies and domestic violence from owning a gun. Other violent misdemeanors such as assault do not prevent the perpetrator from owning a gun.

13. Federal law only requires that FFL holders report stolen guns.

14. Federal law allows the ATF to inspect gun dealers once a year. According to Mayors Against Illegal Guns (2010, p. 26), the ATF's goal is to inspect FFL holders once every 3 years.

**FIGURE 1**  
Percent of Ten Laws in Place, by State



Source: Mayors Against Illegal Guns (2010)

If the above scenario is true then it suggests that states with larger economies would tend to have larger, more developed internal markets for illegal guns. It would also suggest that these larger illegal gun markets would be better positioned to do “business” with prospective buyers in other states. The expectation that, all else equal, larger markets would tend to have greater trade of illegal guns is in line with the gravity model of international trade, a version of which is employed in the empirical section to follow.

In addition to the market thinness brought about by the general illegality of the underground gun market, we can also consider the impact of the differential state laws governing the purchase and sale of guns on the pattern of interstate gun movement. As described in Section II, some states are much more restrictive (with regard to their gun laws discussed earlier) than are others. We can consider the case where we have two potential trading partners who, other than their state gun laws, are identical. If state laws are roughly categorized as being *strict* (i.e., there are many laws in place governing the purchase and sale of guns) and *weak* (i.e., few laws are in place), we can consider the likely trade pattern of guns that would emerge between the two states. We can assume that the costs of “producing” an underground gun (i.e., converting a legal gun into an underground gun) are greater in *strict* states than they would be in *weak* states. If this is the case, then *weak* states would tend to have a comparative advantage in producing underground

**FIGURE 2**  
Predicted Effects of State Gun Laws on Exports of Illegal Guns

		State j	
		<i>Strict</i>	<i>Weak</i>
State i	<i>Strict</i>	Exports <sub>ij</sub> = Exports <sub>ji</sub> (low volume compared to <i>weak, weak</i> )	Exports <sub>ij</sub> < Exports <sub>ji</sub>
	<i>Weak</i>	Exports <sub>ij</sub> > Exports <sub>ji</sub>	Exports <sub>ij</sub> = Exports <sub>ji</sub> (high volume compared to <i>strict, strict</i> )

guns and would thus tend to export them to *strict* states. This is illustrated in Figure 2 which depicts the four possible cases for a pair of states *i* and *j*.

The off-diagonal cases in Figure 2 show net exports flowing from states with *weak* laws to states with *strict* laws, an example, in some sense, of illegal gun flow “seeking the path of least resistance.” As for the two diagonal cases, (*strict, strict* and *weak, weak*), trade is expected to be, more or less, balanced. Concerning the volume of trade, it stands to reason that we would expect the case where both states are *strict* to have the least amount of trade (due to market thinness and high “production costs”

brought about by strict laws) in comparison to the case where both have *weak* laws (and thus thicker markets and lower production costs).<sup>16</sup>

#### A. A Gravity Model for Interstate Movement of Illegal Guns

Tinbergen (1962) was the first to employ a gravity model to explain trade patterns between countries. His original model shows that trade between two countries is proportional to the product of their economic “sizes” and inversely proportional to the distance between them. Since its introduction the gravity model has become widely used to study international trade, including the effects of common currencies on trade flows (e.g., Frankel and Rose 2002) and the benefits of membership in free trade agreements (e.g., Rose 2004). The model has also been expanded to include a host of other factors that may expand trade (e.g., shared borders) or introduce friction that reduces trade (e.g., language differences).

The general form of the gravity equation that has been used to explain trade flows between two locations is provided in the following equation<sup>17</sup>:

$$(1) \quad T_{ij} = \alpha_0 Y_i^{\alpha_1} Y_j^{\alpha_2} (Y_i/P_i)^{\alpha_3} (Y_j/P_j)^{\alpha_4} D_{ij}^{\alpha_5} A_{ij}^{\alpha_6}.$$

The dependent variable  $T_{ij}$  represents the trade from location  $i$  to location  $j$  which is shown to be a function of the gross domestic products (GDPs) of the trading partners, ( $Y_i$  and  $Y_j$ ), their GDPs per capita ( $Y_i/P_i$  and  $Y_j/P_j$ ), the distance, ( $D_{ij}$ ) between the two locations, and other factors that may promote or impede trade ( $A_{ij}$ ). The variables  $\alpha_0$ – $\alpha_6$  are unknown parameters which are to be empirically estimated. The expected signs for  $\alpha_1$  and  $\alpha_2$  are positive indicating that larger economies trade more and  $\alpha_5$  is expected to be negative implying that more distant locations trade less due to increased transportation costs. The expected signs for  $\alpha_3$  and  $\alpha_4$  are dependent upon the type of good(s) flowing between  $i$  and  $j$ . Bergstrand (1989) demonstrates that if a good is capital (labor) intensive then the value for  $\alpha_3$  is expected to be positive

(negative). Furthermore, if the good is a luxury (necessity) then the value for  $\alpha_4$  is expected to be positive (negative). As for the expected sign for  $\alpha_6$ , this will depend on the other factors considered.

Although the model noted above in Equation (1) has been widely used in the study of international trade flows it has been much less used to study interstate trade.<sup>18</sup> For our purpose of analyzing the factors determining the flow of illegal guns between states, our proxy for the export of illegal guns ( $T_{ij}$  in Equation 1) will be the number of guns recovered at crime scenes in 2009 that were originally sold in a different state.<sup>19</sup>

Following the general model shown in Equation (1), crime gun exports between states  $i$  and  $j$  will be estimated as a function of 2009 state GDPs, 2009 state GDPs per capita, the distance between states, and other factors (particularly, differences in state gun laws) that may influence the flow of illegal guns between states. The distance between states is measured in kilometers between the geographic centers of each state pair.<sup>20</sup> In addition to simple distance between states two other location measures are employed. The first is a set of “remoteness” measures for pairs of states, equal to the average distance to all other potential trading partners. The reasoning behind including these remoteness measures is that, given the distance between pairs of states, if two trading partners are geographically far from other potential trading partners then these two are expected to have greater trade with each other.<sup>21</sup> Thus we expect the two remoteness measures (one for the exporter and one for the importer) to have a positive impact on the number of illegal guns flowing between any pair of states. A second location measure is simply a dummy variable that takes the value of 1 if the pair of states share a border, 0 otherwise. Given that we control for distance between trading pairs and their remoteness, one may question why sharing a border would matter. Two possible reasons emerge. First, if trading illegal guns across state lines entails greater risk in comparison to simply intrastate trade

18. Exceptions include Wolf (2000), Yilmazkuday (2009), and Michalski and Ors (2010).

19. Data sources are described in the Appendix.

20. A better approach would be to measure the distance from each state’s illegal gun market to its trading partner’s, but there is no obvious way to geographically identify these locations.

21. Anderson (1979) provides a theoretical justification for including a remoteness measure.

16. The above discussion does not allow us to make any obvious statement about the expected volume of trade between diagonal and off-diagonal cases for Figure 2.

17. See Anderson (1979), Bergstrand (1985, 1989), and Anderson and van Wincoop (2003) for theoretical foundations for the gravity model.

of illegal guns, then crossing fewer state lines would generally entail lesser risk than crossing more. Thus exporting guns to a bordering state would be less risky than exporting guns to a non-bordering state. Second, as noted in Wolf (2000), more trade may occur between bordering states since there would be no competing sellers (from a third state) who would lie in between the exporting and importing states. For both of these reasons we expect that sharing a border will positively affect the export of illegal guns.

Concerning the other factors, (i.e.,  $A_{ij}$  in Equation (1)) that may affect the flow of illegal guns between states, three sets of measures are considered here. The first concerns a potential source of both demand for and supply of illegal guns: the existence of gangs. To the extent that members of gangs need guns to establish some sort of status (see Cook et al. 2007, p. F563) and defend their "turf" from rival gangs, states with greater gang presence (and hence greater demand for underground guns) are likely to have greater imports of illegal guns. In addition, gangs may be a source of supply of guns as they may sell or lend them to others (Cook et al. 2007, p. F567, fn. 20). Thus, all else equal, one would expect that states with a high presence of gangs would tend to have greater trade (both exports and imports) of illegal guns.<sup>22</sup> In order to consider this possibility, information on gang membership per capita by state is used to create a variable *Gang* which takes on the following values<sup>23</sup>:

*Gang* = 0 if <2 gang members per 1,000 people  
 = 1 if between 2 and 5 per 1,000 people  
 = 2 if between 5 and 7 per 1,000 people  
 = 3 if 8 or more per 1,000 people.

Using this breakdown, Illinois had the greatest gang presence (Category 3) followed by California, Nevada, Colorado, and New Mexico (Category 2).

The second set of measures included in  $A_{ij}$  is intended to consider differing degrees of law enforcement across states. If, other things equal, one state devotes more resources to law enforcement than another. Then this may affect

the number of guns being recovered at crime scenes. In order to account for this possibility a variable *Police Expenditures*, equal to the 2007 reported total police protection expenditures (in thousands of dollars per capita), is included for each pair of states.<sup>24</sup> The direction of the effect of more police resources is unclear as increased law enforcement may have both a "deterrent" effect tending to reduce the number of crimes committed with illegal guns as well as an increased "detection" effect where more criminals using guns are apprehended.

The third set of "other factors" affecting the flow of illegal guns between states has to do with the aforementioned differences in state laws governing the purchase and sale of guns. To consider these differences empirically, two approaches are taken. First, an aggregated approach is employed where, for each state  $i$  and its corresponding trade partner  $j$ , the percentage of the ten laws in place is computed. Second, a disaggregated approach is used where dummy variables are created and take the value of 1 if a law is in place, 0 otherwise for each pair of states. For both approaches it is expected that guns will tend to flow from "weak" states to "strict" states as discussed earlier and shown in Figure 2.

#### IV. ESTIMATION APPROACH AND RESULTS

Given that Equation (1) is nonlinear in parameters the most common approach to estimation has been to linearize the equation by taking logs of both sides of the equation and then utilizing ordinary least squares (OLS) to estimate the parameters. Indeed this was the approach taken by Tinbergen in his 1962 study. This approach, however, brings with it several problems. First, the estimates produced are for  $\ln(T_{ij})$  and not  $T_{ij}$  itself. Attempts to simply take the antilog of the predicted log values will produce biased estimates and an alternative approach is needed.<sup>25</sup> More serious than this problem, however, is the likelihood that the log-linear model violates some of assumptions needed to justify the use of OLS. Specifically, as pointed out by Flowerdew and Aitkin (1982) and, more recently, by Santos Silva and Tenreiro (2006) the log-linear model is quite

22. In addition, gangs may transfer guns to affiliated gangs across state lines.

23. Data on gang membership by state are from the U.S. Department of Justice (details are provided in the Appendix). Only ranges were provided, not actual numbers by state.

24. The 2-year lagged data for police expenditures are used to lessen the likelihood of possible endogeneity with the dependent variable.

25. On this issue see, for example, Wooldridge (2009, p. 211).

likely to suffer from heteroskedasticity. Not only will this affect efficiency, Santos Silva and Tenreyro (2006) emphasize that it is also likely to produce inconsistent estimates for the  $\alpha$ s appearing in Equation (1) and thus they recommend estimating a nonlinear model.

Another potentially serious problem that crops up with the log-linear model is the issue of zero values for the dependent variable. Because the log of zero is not computable most researchers estimating gravity equations need to decide on how to deal with cases where the trade between two regions is zero. This is not a trivial problem as there may be many cases of zero values. For example, Santos Silva and Tenreyro (2006) work with 1990 data for 136 countries which yields a total of 18,360 observations (136  $\times$  135 pairs).<sup>26</sup> However, when computing the natural log of trade flows, their resulting sample shrinks to 9,613 observations implying that a total of 8,474 observations (about 48%) are zero values. Several solutions to the zero-value problem have been implemented. One is simply to drop zero-value cases (e.g., Frankel 1997 and McCallum 1995). However, unless the zero values are randomly assigned this will likely produce a selection bias in the results. A second solution has been to add an arbitrarily small amount (e.g., 0.1) to all trading values and in doing so avoiding zero values (e.g., McCallum 1995; Raballand 2003; Wang and Winters 1991). Unfortunately, it has been demonstrated by both Flowerdew and Aitkin (1982) and Santos Silva and Tenreyro (2006) that such an approach can produce misleading results as the estimated coefficients can be sensitive to the constant value added to trade flows.<sup>27,28</sup>

Another approach, one that is used in this article, is to estimate Equation (1) using a Poisson pseudo-maximum-likelihood estimator. Both Flowerdew and Aitkin (1982) and Santos Silva and Tenreyro (2006) advocate the use of this estimator.<sup>29</sup> The Poisson estimator is

26. Their trade data come from Feenstra, Lipsey, and Bowen (1997).

27. Flowerdew and Aitkin (1982) find that as the constant added to trade values increases the absolute value of the estimated coefficients decrease and the  $R^2$  values increase (see Table 1, p. 195).

28. A third approach for dealing with zero values is to use a tobit estimation method (e.g., Rose 2000). However, Linders and de Groot (2006) argue that using a tobit model is generally inappropriate when estimating a gravity equation.

29. Santos Silva and Tenreyro apparently were unaware of the Flowerdew and Aitkin (1982) article as the latter was not referenced in their 2006 paper.

**TABLE 1**  
Summary Statistics ( $n = 2, 450$ )

	Mean	SD	Min	Max
Trade	17.080	49.640	0	1020
2009 GDP (millions \$)	278569.3	332534.6	25121	1884452
2009 GDP per capita (millions \$)	0.045	0.008	0.032	0.066
Distance (km)	1979.39	1468.75	62.26	8229.41
Contiguous	0.086	0.280	0	1
Remote (km)	1973.04	848.73	1285.67	6596.54
Gang	0.70	0.70	0	3
2007 Police expenditure (\$1,000s per capita)	0.048	0.024	0.012	0.123
Percent laws	33.60	31.68	0	100

well suited for the gravity model as it produces consistent estimates of the parameters, it is found to be robust to various forms of heteroskedasticity, and it allows for the dependent variable to have zero values. Thus the main regression results appearing below will be generated using the Poisson estimator. For completeness, however, several robustness checks using alternative estimation approaches are also provided.

To estimate the model shown in Equation (1) data on the movement of illegal guns between states is required. While there are no comprehensive data available on the movement of illegal guns per se, as described briefly in the introduction the ATF uses the serial numbers on guns recovered at crime scenes to determine the states from which these guns originated. The assumption in this article is that trace data for crime scene guns produce a picture that closely resembles that of illegal gun movement in the United States generally. Data on recovered crime scene guns for the 50 U.S. states in 2009 are used to construct a data set containing 2,450 observations (50  $\times$  49 state pairs).<sup>30</sup> Summary statistics, which are provided in Table 1, show that the typical state pair witnessed exports of approximately 17 crime guns in 2009, each traveling an average of nearly 2,000 km.

Table 2 provides a brief description of the ten laws and their variable names which are considered jointly and separately in the regression analysis to follow.

30. Washington, DC is excluded from the analysis.

**TABLE 2**  
Brief Description of State Laws Affecting Gun  
Purchases and Sales

State Laws	Variable Names
Local parallel law for straw purchasing	<i>Straw</i>
Local parallel law for falsifying purchaser information	<i>Falsify</i>
Local parallel law for failure by dealer to conduct background check	<i>Background</i>
Requires background checks for all handgun sales at gun shows	<i>Background Shows</i>
Requires purchase permit for all handgun purchases	<i>Permit</i>
Grants local law enforcement discretion to deny concealed carry permits	<i>Discretion</i>
Prohibits gun possession by violent misdemeanants	<i>Misdemeanants</i>
Requires reporting lost or stolen guns	<i>Lost</i>
Requires or allows local control of gun regulations	<i>Local</i>
Requires or allows dealer inspections	<i>Inspect</i>

#### A. Results for Aggregate State Laws

Four versions of the model shown in Equation (1) are estimated and the results are presented in Table 3. In all four cases the dependent variable ( $T_{ij}$ ) is the number of guns purchased in state  $i$  that were recovered at a crime scene in state  $j$ . The first regression estimates Equation (1) but omits the measures for differential gun laws. The second and third regressions include gun laws in an aggregated form, with the latter regression including an interaction effect. The fourth regression includes gun laws in a disaggregated form. All four regressions were estimated using the Poisson pseudo-maximum-likelihood estimator with robust standard errors.<sup>31</sup>

In viewing the results in Table 3, several consistent outcomes are found in all four regressions. First, trade in illegal guns is increasing with the GDPs of both trading partners. Elasticity with respect to exporting state GDP is in the range of 0.83 to 0.97. The estimated elasticity

31. Anderson and van Wincoop (2003) argue that correctly specified gravity models should incorporate country-specific (or in this case, state-specific) fixed effects. However, working with only a cross-section of data, the inclusion of state-specific fixed effects would mean that only bilateral variables could be identified. Given the primary goal of this article is to consider the effects of state-specific gun laws on the movement of illegal guns, fixed effects are excluded from the regressions.

with respect to importing GDP is slightly higher and ranges from 1.02 to 1.1.

Regarding GDP per capita, we see a consistent pattern in signs for the estimated coefficients: they are negative and significant in all cases. Following Bergstrand's (1989) model, the negative coefficient to the exporter's GDP suggests that the "production" of illegal guns tends to be labor intensive, a result that seems quite plausible given the "product." The estimated coefficients are somewhat large and suggest that a 1% increase in the exporting state's per capita GDP reduces exports of crime guns by 2.4% to 3.8%, other things equal. This coefficient is likely picking up more than simply indicating labor intensity in production. It may also be capturing an income effect. Specifically, exporting states with larger per capita GDPs would tend to have more affluent populations who may be less inclined to participate in the movement of illegal guns. The negative coefficients to the importer's GDP, again following Bergstrand (1989), suggests that purchasers of illegal guns view them as necessities. This too, seems quite plausible given that we are considering crime scene guns as the "good" purchased.

The distance and location measures all have the expected signs and are significant at the 1% level. The estimated elasticity with respect to distance between trading partners is in the range of -0.94 to -1.02. Sharing a border tends to strongly increase the exports of traced crime guns as the estimated coefficients for the variable *Contiguous* suggest an increase of between 68.4% and 82.4%.<sup>32</sup> Both the remoteness measures are positive and indicate that pairs of states that are more isolated from other potential trading partners tend to witness increased trade in illegal guns, all else equal.

The presence of gangs in either the exporting or importing state tends to increase trade in illegal guns. The two estimated coefficients are positive in all three regressions and significant in all but the case of exporter gang presence in Regression (4). Using the results of Regression (2), as an exporting state goes from, say, *Gang* Category 1 (between 2 to 4 gang members per 1,000 people) to Category 2 (between 5 and 7 gang members per 1,000 people) traced illegal gun exports tend to increase by about 17.1%. As for the gang presence in the importing state, a similar change in *Gang* categories tends to

32. Computed as  $[\exp(\alpha) - 1] \times 100$ , where  $\alpha$  is the estimated coefficient to the *Contiguous* dummy variable.



**TABLE 3**  
Poisson Regression Estimates for Interstate Crime Gun Exports

	Dependent Variable, $T_{ij}$			
	(1)	(2)	(3)	(4)
$\ln(GDP_i)$	0.826*** (0.0335)	0.965*** (0.0392)	0.962*** (0.0402)	0.915*** (0.0369)
$\ln(GDP_j)$	1.103*** (0.0338)	1.066*** (0.0308)	1.062*** (0.0308)	1.024*** (0.0298)
$\ln(GDP_i \text{ per capita})$	-3.810*** (0.277)	-2.780*** (0.313)	-2.722*** (0.319)	-2.353*** (0.279)
$\ln(GDP_j \text{ per capita})$	-0.827*** (0.295)	-0.857*** (0.236)	-0.776*** (0.229)	-0.664*** (0.216)
$\ln(\text{distance}_{ij})$	-0.937*** (0.0496)	-1.010*** (0.0544)	-1.023*** (0.0570)	-1.005*** (0.0458)
<i>Contiguous</i>	0.601*** (0.0984)	0.521*** (0.0899)	0.529*** (0.0908)	0.553*** (0.0762)
$\ln(\text{remote}_i)$	0.965*** (0.135)	0.725*** (0.166)	0.703*** (0.166)	0.723*** (0.163)
$\ln(\text{remote}_j)$	0.516*** (0.165)	0.522*** (0.163)	0.507*** (0.167)	0.821*** (0.149)
<i>Gang<sub>i</sub></i>	0.0989** (0.0415)	0.158*** (0.0472)	0.140*** (0.0468)	0.0417 (0.0528)
<i>Gang<sub>j</sub></i>	0.216*** (0.0669)	0.163** (0.0662)	0.150** (0.0657)	0.193*** (0.0676)
<i>Police Expenditures<sub>i</sub></i>	0.0678 (0.0929)	0.356*** (0.0992)	0.358*** (0.0990)	0.137 (0.0890)
<i>Police Expenditures<sub>j</sub></i>	0.263*** (0.0837)	0.184** (0.0807)	0.173** (0.0806)	0.0992 (0.0800)
<i>Percent Laws<sub>i</sub></i>		-0.0136*** (0.00131)	-0.00943*** (0.00157)	
<i>Percent Laws<sub>j</sub></i>		0.00203* (0.00119)	0.00441*** (0.00142)	
<i>Percent Laws<sub>i</sub> × Percent Laws<sub>j</sub></i>			-8.68e - 05*** (2.50e - 05)	
<i>Straw<sub>i</sub></i>				-0.0606 (0.118)
<i>Straw<sub>j</sub></i>				0.215** (0.0932)
<i>Falsify<sub>i</sub></i>				-0.0236 (0.0928)
<i>Falsify<sub>j</sub></i>				-0.0676 (0.0847)
<i>Background<sub>i</sub></i>				0.0434 (0.0873)
<i>Background<sub>j</sub></i>				0.185*** (0.0685)
<i>Background Shows<sub>i</sub></i>				-0.310** (0.124)
<i>Background Shows<sub>j</sub></i>				-0.136 (0.109)
<i>Permit<sub>i</sub></i>				-0.178 (0.154)
<i>Permit<sub>j</sub></i>				0.289* (0.152)
<i>Discretion<sub>i</sub></i>				-0.209** (0.0931)
<i>Discretion<sub>j</sub></i>				-0.106 (0.104)
<i>Misdemeanants<sub>i</sub></i>				-0.232 (0.141)
<i>Misdemeanants<sub>j</sub></i>				0.00573 (0.0976)
<i>Lost<sub>i</sub></i>				-0.608*** (0.119)
<i>Lost<sub>j</sub></i>				0.146 (0.108)
<i>Local<sub>i</sub></i>				-0.0522 (0.153)
<i>Local<sub>j</sub></i>				-0.0508 (0.163)
<i>Inspect<sub>i</sub></i>				0.0914 (0.0784)
<i>Inspect<sub>j</sub></i>				-0.141** (0.0562)
Constant	-39.72*** (2.397)	-34.50*** (2.530)	-33.73*** (2.534)	-34.69*** (2.408)
Observations	2, 450	2, 450	2, 450	2, 450
Pseudo- $R^2$	0.753	0.782	0.784	0.804

Notes: Robust standard errors in parentheses.

\*\*\*  $p < 0.01$ ; \*\*  $p < 0.05$ ; \*  $p < 0.1$ .

increase the number of traced illegal guns by about 17.7%, other things equal.

The two variables for *Police Expenditures* are positive in all regressions. The exporting state's police expenditures are significant in Regressions (2) and (3), while for the importing state this measure is significant in all but Regression (4). Taken together, these results suggest that increasing the amount of resources spent on law enforcement increases the number of crime scene guns recovered. The positive

coefficients suggest that the "detection" effect is stronger than the "deterrent" effect as discussed earlier.

Moving now to the effects of state gun laws, we can see in Regressions (2) and (3) that aggregate differences in gun laws do appear to affect the pattern of illegal gun movement. Both exporter and importer *Percent Laws* measures are significant, with the former being negative and the latter being positive. This pattern of signs for the two coefficients is consistent

with the predictions provided in Figure 2 where exports should be greater when the exporting state has “weak” gun laws and the importing state has “strict” gun laws. If the typical exporting state goes from having 3 of the ten laws in place (the approximate average for all 50 states) to four, the traced export of illegal guns is predicted to decline by about 8.7%. In the case of the importing state, a similar change in laws would reduce illegal gun trade by about 1.4%.<sup>33</sup> These marginal effects with respect to *Percent Laws* assume that each of the ten laws has a similar effect on the movement of crime guns. However, there is no reason to expect that, say, stronger state laws against straw purchases should have the same impact on the movement of illegal guns as would stronger laws with regard to required background checks by dealers. Determining the marginal effect of specific laws on the movement of illegal guns can be done by examining the results from Regression (4). Before doing so, however, it is interesting to consider the effects of interacting *Percent Laws<sub>i</sub>* with *Percent Laws<sub>j</sub>*. The results in Regression (3) show that the estimated coefficient to the interaction effect is negative and significant while the signs and significance levels for the *Percent Laws<sub>i</sub>* and *Percent Laws<sub>j</sub>* remain, more or less, the same. The implication is that, for state *i*, as gun laws become more restrictive this will tend to reduce gun exports more so when their partner’s state laws are highly restrictive. Furthermore, the increase in state *i*’s exports to state *j* as state *j*’s laws become more restrictive will be smaller when state *i*’s laws are more restrictive. That is, the movement from “weaker” to “stricter” gun laws on the part of one state will tend to have a stronger effect in reducing the export of guns when the other state has strict gun laws to begin with.

### B. Results for Individual State Laws

To try to determine which laws seem to be more effective than others in reducing illegal gun exports we now consider the results for Regression (4) in Table 3. Given that ten state laws are being considered for both the exporting and importing states, a total of 20 estimated coefficients for state laws are presented in Regression (4). Recalling the discussion in

33. Computed as  $[\exp(\alpha\Delta x) - 1]$ , where  $\alpha$  is the estimated coefficient to *Percent Laws* (exporter or importer) and  $\Delta x$  is the change in percentage points going from 3 to 4 laws out of 10 (i.e.,  $\Delta x = 6.7$  in this case).

Section III as well as Figure 2, the expected pattern for illegal guns flow is from states with “weak” gun laws to those with “strict” gun laws. This suggests then, that the ten coefficients for the exporting state laws should be negative and the ten for the importing states should be positive.

Considering the exporting states’ laws, eight of the ten laws have the predicted sign; however, only three are found to be significant at the 5% level or better. The three laws found to be important in reducing traced illegal gun exports are state laws requiring background checks for purchases at gun shows (*Background Shows<sub>i</sub>*), laws granting local law enforcement the discretion to deny concealed carry permit (*Discretion<sub>i</sub>*), and laws requiring that owners report guns that are lost or stolen (*Lost<sub>i</sub>*). The coefficients for *Background Shows<sub>i</sub>* and *Discretion<sub>i</sub>* suggest that states with these laws tend to export 25.6% and 18.9% fewer illegal guns, respectively. The coefficient to *Lost<sub>i</sub>* has the largest impact with an estimated effect of reducing traced illegal gun movement by approximately 45.6% compared to states that do not have such a law. As an illustration of the predicted impact of enacting such a law, we can consider the case of Virginia’s exports of crime guns to New York. According to the data used in this study, Virginia exported 443 guns to New York in 2009. Given the results reported in Table 3, if Virginia had in place a law requiring that lost or stolen guns be reported to local authorities then the model predicts that approximately 202 fewer guns would have been exported to New York.<sup>34</sup> Given that these are guns recovered at crime scenes, one could speculate that with 202 fewer guns exported to New York, the number of crimes involving guns New York would have been less.<sup>35</sup>

34. This number is admittedly small in comparison to total gun ownership in New York which is likely to be in the millions. However, guns recovered at crime scenes and gun ownership at large are two different things. The vast majority of guns in the United States are legally owned by law-abiding citizens and are typically not involved in criminal acts. Guns recovered at crime scenes are more likely to have been illegally owned and, by definition, are involved in criminal acts. The more relevant comparison, then, would be the estimated 202 fewer guns recovered at crime scenes in New York relative to the number of illegally owned guns in New York. Unfortunately, the data needed for this comparison are not available.

35. The linkage between exports of crime guns and crimes involving illegal guns in the importing state is not considered in this article and is left for future research. Furthermore, any such link would be difficult to establish as the reduction of imports from one state may be substituted with imports from another.

As for gun laws in place in importing states, three emerge with positive, significant coefficients. These include local laws strengthening the federal law against straw purchases (*Straw<sub>j</sub>*), local laws strengthening the federal law that requires dealers conduct background checks of purchasers (*Background<sub>j</sub>*), and state laws requiring all gun purchasers obtain a permit to purchase a gun (*Permit<sub>j</sub>*). The largest effect on illegal gun imports is *Permit<sub>j</sub>* with an estimated impact of increasing traced imports by 33.5% compared to states without this law. The estimated impact of *Straw<sub>j</sub>* is a 24% increase and for *Background<sub>j</sub>* it is 20.3%. One coefficient, that for *Inspect<sub>j</sub>*, is negative and significant at the 5% level. This finding implies that importing states with a law that requires (or allows) state inspections of gun dealers tend to have approximately 13.2% fewer gun imports compared to states that do not have such a law. One possible explanation for this contrary finding may have to do with the discussion in Section II above on how legal guns become illegal guns. That is, corrupt, local licensed dealers in the importing state may facilitate the transformation of legal guns imported from another state into illegally owned guns by participating in negligent or illegal sales. For example, local dealers may fail to conduct or do adequate background checks which ultimately place guns into the hands of those who would otherwise not be allowed to purchase them. In this scenario greater oversight of these dealers may reduce their ability to facilitate such transformations.

### C. Matching Laws

An alternative approach to studying the effects of individual state laws on the flow of crime guns between states is to consider cases where states have matching laws. For example, consider the state law requiring the notification of local officials when a gun is lost or stolen (*Lost*). How do the effects of this law on the movement of illegal guns between states differ when both states have the law in place in comparison to the case when only one state has it? An analysis of this kind will allow us to better test the predicted trade flows shown in Figure 2 as it allows a comparison of the four cases depicted in the matrix. In order to conduct such a test a series of dummy variables were constructed to indicate three cases: state *i* (the exporter) has the law but state *j* (the importer)

**TABLE 4**  
Matching Laws Analysis

Laws	State and/or Partner Has Law?		
	No–Yes	No–No	Yes–No
Straw	–0.009	–0.193	–0.313**
Falsify	–0.019	0.089	0.013
Background	–0.123	–0.151	–0.317***
Background Shows	0.355**	0.437***	0.256
Permit	0.157	–0.118	–0.384*
Discretion	0.321**	0.398***	0.253**
Misdemeanants	0.425**	0.337*	0.277
Lost	0.943***	0.717***	0.341
Local	0.368	0.341	0.465*
Inspect	–0.097	0.031	0.121

Notes: Omitted case: both states have laws (i.e., “Yes–Yes”).

\*\*\*  $p < 0.01$ ; \*\*  $p < 0.05$ ; \*  $p < 0.1$ .

does not, state *j* has the law but state *i* does not and lastly, neither state has the law. The base case, then, is when both states have the particular law in place. The resulting number of dummy variables covering these cases for the ten laws considered comes to 30. In order to simplify the presentation of the results of this regression, Table 4 shows only the 30 estimated coefficients, grouped by case, for the ten state laws considered.<sup>36</sup>

As is evident from Table 4, in the first case (“No–Yes”) four laws, *Background Shows*, *Discretion*, *Misdemeanants*, and *Lost* appear to significantly increase exports between states when the exporting state does not have the law in place and the importing state does, in comparison to the case when both have the laws in place. Thus, with respect to Figure 2, this suggests that the exports from *i* to *j* in the lower left cell would tend to be greater than that of the upper left cell.

The second case (“No–No”) results show that when both state do not have laws for *Background Shows*, *Discretion*, *Misdemeanants*, and *Lost*, state *i* tends to export significantly more illegal guns to state *j* than is the case when both states have these laws. Regarding Figure 2, this suggests that the volume of trade of the bottom right cell exceeds that of the upper left.

Finally, for the third case (“Yes–No”), we do not see a consistent pattern. The results

36. The estimates of the other ten gravity model covariates are reported in Table A2 in the Appendix.

for *Straw*, *Background*, and *Permit* produce negative and significant coefficients suggesting that when the exporting state has these laws in place and the importing state does not that traced exports tend to be less than in comparison to the case when both states have these laws. However, for *Discretion* and *Local*, the opposite appears to be true.

#### D. Robustness Checks

As noted earlier in this section, there have been various approaches to estimating gravity models of this type. In order to consider the robustness of the results shown in Table 3, six alternative regressions have been estimated for the model with aggregate state laws. The results of these alternative estimations appear in Table 5.

The first two regressions estimate a log-linear version of Equation (1) using OLS. Regression (1) omits all cases where trade is zero (539 observations or 22% of the total possible). We can see that the parameter estimates in this regression differ, sometimes substantially, compared to Regression (2) in Table 3. The coefficient to *Percent Laws<sub>i</sub>* is similar in size and significance in comparison to that found earlier. The coefficient to *Percent Laws<sub>j</sub>*, however, is now negative, which is contrary to what is expected. Regression (2) is similar to the first, but adds 0.1 to the  $T_{ij}$  before taking the natural log, thus preserving all observations. We see that, in comparison to Regression (1) the estimated coefficients are larger (in absolute terms). The estimated coefficients to *Percent Laws<sub>i</sub>* and *Percent Laws<sub>j</sub>* continue to have the same signs and are significant as those found in Regression (1), again with the latter having the wrong sign. It is clear from these results that the log-linear approach with OLS is likely to produce misleading estimates of Equation (1).

Of the 50 states considered, two, Alaska and Hawaii, are clear outliers when it comes to distance to their trading partners. The average distance between geographic centers of the 48 contiguous states is 1,656 km. The average distance between Alaska and the contiguous 48 states is 4,766 km, and for Hawaii it is 6,587. In order to test for outlier effects of these two states, Regression (2) of Table 3 is re-estimated after excluding Alaska and Hawaii. The results, shown in Regression (3) of Table 5, are quite similar to those found earlier with the notable

difference that the coefficient to  $\ln(\text{remote}_i)$  is somewhat smaller when these two states are excluded. As for the estimated coefficients for *Percent Laws<sub>i</sub>* and *Percent Laws<sub>j</sub>*, they have the same sign and are very similar in size and significance in comparison to Regression (2) of Table 3.

In Burger, van Oort, and Linders (2009) the authors restate the message noted in Santos Silva and Tenreyro (2006) regarding the appropriateness of the Poisson estimation approach for the gravity model. They also note, however, that the Poisson estimation approach may be problematic when there are an excessive number of zeros in for the dependent variable. In such a case, they argue that the zero-inflated Poisson estimation method may be a better approach. In order to consider this possibility Regression (4), Table 5 presents the zero-inflated Poisson estimation of Equation (1). As is evident, the results found earlier are robust to this alternative estimation method.<sup>37</sup>

Another possible complicating factor has to do with the potential difference in intensity with which gun laws are enforced and crime guns analyzed across states. It may be the case that differences in the dependent variable,  $T_{ij}$ , are being driven in part by the differences in the allocation of law enforcement to crime gun recovery, differences in the propensity for the use of guns during a crime, or the likelihood that a gun used in a crime will in fact be submitted to the ATF for a trace. In order to consider this possibility, an alternative dependent variable, one that conditions on the number of traced guns recovered by the importing state, can be employed. Specifically, we can compute a measure  $T_{ij}/M_j$  which is the number of guns flowing from state  $i$  to state  $j$ , divided by the sum of all guns flowing into state  $j$ . Regression (5) in Table 5 shows the regression results when this new dependent variable is used. The majority of the estimated coefficients display a similar pattern in terms of sign and significance to the original Regression (2) shown in Table 3 with a few notable differences. Specifically,  $\ln(\text{GDP}_j)$  and *Gang<sub>j</sub>* are no longer significant while *Police Expenditures<sub>j</sub>* and  $\ln(\text{GDP}_j)$  per capita now have different signs. As for

37. Another possible approach would be the zero-inflated negative binomial estimation. Burger, van Oort, and Linders (2009), however, find the zero-inflated Poisson model tends to outperform the zero-inflated negative binomial estimator for gravity models.

**TABLE 5**  
Alternative Estimation Methods for the Interstate Exports of Crime Guns

	(1) ln(T <sub>i,j</sub> )	(2) ln(T <sub>i,j</sub> + 0.1)	(3) Without Alaska and Hawaii	(4) Zero-Inflated Poisson	(5) T <sub>i,j</sub> /M <sub>j</sub>	(6) Brady Measures
ln(GDP <sub>i</sub> )	0.781*** (0.0203)	0.988*** (0.0270)	0.995*** (0.0417)	0.947*** (0.0396)	0.759*** (0.0323)	0.988*** (0.0408)
ln(GDP <sub>j</sub> )	0.976*** (0.0210)	1.314*** (0.0274)	1.063*** (0.0330)	1.033*** (0.0334)	-0.0432 (0.0286)	1.112*** (0.0388)
ln(GDP <sub>i</sub> per capita)	-1.023*** (0.138)	-1.319*** (0.185)	-2.979*** (0.321)	-2.737*** (0.313)	-1.719*** (0.217)	-2.760*** (0.314)
ln(GDP <sub>j</sub> per capita)	-0.243* (0.130)	-0.377*** (0.185)	-0.881*** (0.239)	-0.833*** (0.245)	0.392** (0.169)	-0.514* (0.282)
ln(distance <sub>i,j</sub> )	-0.842*** (0.0369)	-1.085*** (0.0475)	-1.034*** (0.0546)	-0.988*** (0.0547)	-0.956*** (0.0468)	-1.026*** (0.0541)
Contiguous	0.710*** (0.0751)	0.809*** (0.0907)	0.507*** (0.0898)	0.526*** (0.0892)	0.630*** (0.0718)	0.507*** (0.0917)
ln(remote <sub>i</sub> )	0.938*** (0.0805)	1.279*** (0.104)	0.592*** (0.177)	0.704*** (0.165)	0.904*** (0.134)	1.220*** (0.138)
ln(remote <sub>j</sub> )	1.017*** (0.0842)	1.108*** (0.102)	0.592*** (0.175)	0.562*** (0.171)	1.146*** (0.116)	0.571*** (0.169)
Gang <sub>i</sub>	0.0614** (0.0253)	0.124*** (0.0337)	0.178*** (0.0467)	0.152*** (0.0469)	0.136*** (0.0360)	0.126*** (0.0413)
Gang <sub>j</sub>	0.132*** (0.0277)	0.169*** (0.0362)	0.160** (0.0661)	0.160** (0.0673)	-0.0179 (0.0396)	0.188*** (0.0661)
Police Expenditures <sub>i</sub>	0.0892** (0.0447)	0.134*** (0.0586)	0.366*** (0.105)	0.358*** (0.0992)	0.118* (0.0664)	0.293*** (0.0940)
Police Expenditures <sub>j</sub>	0.197*** (0.0490)	0.360*** (0.0602)	0.152* (0.0873)	0.165* (0.0849)	-0.173*** (0.0649)	0.272*** (0.0793)
Percent Laws <sub>i</sub>	-0.0134*** (0.000679)	-0.0174*** (0.000915)	-0.0134*** (0.00137)	-0.0134*** (0.00132)	-0.0123*** (0.000917)	
Percent Laws <sub>j</sub>	-0.00330*** (0.000711)	-0.00596*** (0.000904)	0.00247** (0.00123)	0.00231* (0.00120)	-0.000555 (0.000998)	
Brady Score <sub>i</sub>						-0.0226*** (0.00301)
Brady Score <sub>j</sub>						-0.00248 (0.00186)
Constant	-30.90*** (1.235)	-39.96*** (1.620)	-35.03*** (2.610)	-33.99*** (2.548)	-25.60*** (2.002)	-38.03*** (2.499)
Observations	1,911	2,450	2,256	2,450	2,450	2,450
R <sup>2</sup> /Pseudo R <sup>2</sup>	0.754	0.712	0.781		0.144	0.778

Notes: Robust standard errors in parentheses.  
\*\*\*  $p < 0.01$ ; \*\*  $p < 0.05$ ; \*  $p < 0.1$ .

the two variables controlling for differences in state gun laws *Percent Laws<sub>i</sub>*; remains negative and significant at better than the 1% level. *Percent Laws<sub>j</sub>*, however, is now insignificant. It is interesting to note that nearly all of the changes in this regression compared to Regression (2) in Table 3 are for the estimated coefficients to the *j* (importing state) covariates. This is likely due to the fact that the dependent variable in Regression (5) contains  $M_j$  which captures much of the variation that was previously explained by the *j* covariates in Regression (2).<sup>38</sup>

Finally, as noted in Section II, the ten state gun laws considered in this article were taken from Mayors Against Illegal Guns (2010). However, other rankings on the strictness of state gun laws exist. For example, the group called the Brady Campaign to Prevent Gun Violence produces a 100-point state “scorecard” that ranks states based on the group’s perception of how well a state’s gun laws work to prevent gun violence. States with values closer to 100 are considered to be more restrictive with regard to gun laws. In an effort to compare their index to the one used in this article a regression identical to Regression (2) of Table 3 was estimated, except *Percent Laws<sub>i</sub>* and *Percent Laws<sub>j</sub>* are replaced with *Brady Score<sub>i</sub>* and *Brady Score<sub>j</sub>*. The results, shown in Regression (6) of Table 5, produce similar estimates for most of the other covariates. The coefficients to *Gang<sub>j</sub>* and the two *Police Expenditures* variables, however are no longer significant. As for the two scorecard measures, the estimated coefficient to *Brady Score<sub>i</sub>* is negative and significant while that of *Brady Score<sub>j</sub>* is not important in the regression. This model, however, produces a slightly poorer fit based on pseudo  $R^2$ .<sup>39</sup>

Overall, the results of these robustness checks support the basic findings shown in Table 3. Namely that state laws do appear to have an

impact on the movement of illegal guns between states and they do so in a predictable way: states with “weak” gun laws tend to be exporters to states with “strict” gun laws.<sup>40</sup>

## V. CONCLUSIONS AND POLICY PRESCRIPTIONS

It is interesting to consider how laws regarding the right to own guns have given rise to both legal and illegal gun markets. The emergence of legal gun markets has its basis in the Second Amendment of the U.S. Constitution. In addition, the Gun Control Act of 1968 was designed to allow states to protect themselves from each other, thereby allowing them to choose different levels of regulation. However, federal and state laws restricting gun ownership for some individuals have given rise to the illegal market for guns. And while the recent 2010 Supreme Court decision in the *McDonald v. Chicago*<sup>41</sup> case will likely limit the degree to which state laws inhibit gun ownership, it remains clear that there continue to be substantial differences between states when it comes to how strict their gun laws are. This being the case, then the emergence and functionality of illegal gun markets should also differ across states. Using a gravity model for the flow of illegal guns between states (as proxied by the ATF’s tracing of crime scene guns), the empirical results in this article do indeed find that differences in state laws can explain, in part, the pattern of illegal gun flow across state lines. Specifically, guns tend to flow from states where gun laws are weak to states where gun laws are strict.<sup>42</sup>

This article has purposely sidestepped the debate over whether gun ownership leads to more or less violent crime, (i.e., the “more guns, less crime” view of Lott 1998 vs. “more guns,

38. A robustness check of Regression (4) in Table 3, but using  $T_{ij}/M_j$  as the dependent variable, also produced a similar pattern in terms of sign and significance for the estimated coefficients compared to the original regression. Again, the *j* measures were the ones most likely to be affected. Two key laws, *Discretion<sub>i</sub>* and *Lost<sub>i</sub>* continue to be strong determining factors in the model with signs consistent with those found in the original regression.

39. The Brady Scorecard measure contains components, such as state laws on child safety locks and laws on the ability to have a gun in a public place, that are less likely to be relevant for the determination of illegal gun flows across state lines.

40. At the suggestion of one anonymous referee, regressions using state crime rates in place of state GDPs were estimated. The resulting regressions produced similar estimated coefficients for the other covariates, but the overall goodness of fit was poorer than the regressions using state GDPs.

41. *McDonald v. Chicago*, 561 U.S. \_\_\_, 130 S.Ct. 3020 (2010).

42. Shortly after completing the first draft of this article a similar analysis, developed independently, by Knight (2011) on differential state gun policies and illegal gun flows appeared. Knight’s paper focuses more on the microeconomic theory of interstate gun flows whereas this article contains a broader set of empirical determinants.

more crime” view of Duggan (2001).<sup>43</sup> However, if the goal of state gun laws is to reduce the flow of illegal guns between states then the empirical results in this article show that several state laws, if enacted by an exporting state, may work to reduce this flow.<sup>44</sup> Specifically, laws requiring background checks at gun shows, laws granting local officials discretion to deny an individual a permit to carry a concealed gun, laws disallowing gun possession by violent misdemeanants, and laws requiring the reporting of lost or stolen guns to local officials all work to reduce the flow of illegal guns from one state to another based on data for traced guns. The effect of unilaterally enacting such laws, however, may have somewhat of a perverse effect. For example, the results noted above suggest that if state  $i$ , say, enacts a law that requires the reporting of lost guns to local authorities, and state  $j$  does not have such a law, then state  $i$  may witness an increase in imports of illegal guns.<sup>45</sup> Thus, in order for such a policy to be effective in generally reducing the flow of illegal guns both states would need to have the law in place. In other words, these kinds of laws would be most effective if they were applied nationally.

Finally, in addition to laws affecting gun ownership, the empirical results in this article show that the presence of gangs, in both the exporting and importing states, facilitates the

43. I do, however, think it is amusing to note Ozzy Osbourne’s view on this matter who said in a 1998 interview, “I keep hearing this [expletive] thing that guns don’t kill people, but people kill people. If that’s the case, why do we give people guns when they go to war? Why not just send the people?” (*New York Times Magazine*, June 28, 1998, “Questions for Ozzy Osbourne,” <http://www.nytimes.com/1998/06/28/magazine/sunday-june-28-1998-questions-for-ozzy-osbourne.html>. Accessed June 10, 2011).

44. It would be interesting to separate out the effects of the laws considered in this article on gun trafficking versus other sources of crime gun exports (such as a lawful owner who moves to another state and eventually has their gun stolen). One possible way to approach this issue would be to use ATF’s “time-to-crime” measure which tracks the length of time between the original sale of a gun and its date of recovery at a crime scene. The idea here is that guns with a short time-to-crime are more likely to be trafficked. Unfortunately the data available at the *Trace the Guns* website (see the Appendix) only has aggregate values by state thus preventing its inclusion in this study.

45. A Wald test for the equality of the estimated coefficients to *Lost* in the “No–Yes” vs. “No–No” cases of Table 4 rejects the null hypothesis at the 0.02 significance level.

movement of illegal guns. Thus, any comprehensive policy designed to reduce the movement of illegal guns would have to address this aspect of the market.

Regarding directions for future research, several come to mind. First, adding additional years of ATF gun trace data (if and when they become available) would be a step forward as dyadic fixed-effects could then be added to the gravity model. A second way forward, should the data become available, would be to incorporate the ATF’s time-to-crime measure for traced guns. Having these data would possibly provide the researcher with a way of identifying the differential impact of state laws on actual gun trafficking as opposed to other means of transmission of guns across state lines. Lastly, another way forward would be to enter into the debate noted above regarding gun ownership and violent crime to see if differential state laws affecting crime gun exports ultimately impact state violent crime rates.

## I. APPENDIX: DATA SOURCES

### A. *Dependent Variable*

Data on the 2009 recovery of crime scene guns was assembled by accessing the *Trace the Guns* interactive website maintained by the group Mayors Against Illegal Guns and found at <http://www.tracetheguns.org/>. Export values were entered for each state pair. Note that the total guns exported may differ from the figure shown on the website as exports/imports to U.S. territories (e.g., Puerto Rico) were not included.

### B. *Independent Variables*

State GDPs—Bureau of Economic Analysis, Regional Economic Accounts (<http://www.bea.gov/regional/gsp/>).

State Population—U.S. Bureau of the Census (<http://2010.census.gov/2010census/data/>)

Distance—author’s calculation of great circle distances based on the geographic centers of states.

Gang—U.S. Department of Justice, National Gang Intelligence Center, National Gang Threat Assessment 2009, Gang membership per capita, by state (<http://www.justice.gov/ndic/pubs32/32146/appa.htm>).

Police Expenditures—U.S. Department of Justice, Bureau of Justice Statistics, Table 9: Justice System Expenditure of State Governments by Activity and Character and Object, fiscal year 2007 (<http://bjs.ojp.usdoj.gov/index.cfm?ty=pbdetail&iid=2315>).

Percent Laws and individual laws—Mayors Against Illegal Guns (2010), (see references).

Brady Score—The Brady Campaign to Prevent Gun Violence (<http://www.bradycampaign.org/xshare/bcam/stategunlaws/scorecard/StateRatings.pdf>, Accessed June 8, 2011).

**TABLE A1**  
Summary of States Having Laws Governing Purchase and Sale of Firearms

State	Straw	Falsify	Background	Background			Misdemeanants	Lost	Local	Inspect
				Shows	Permit	Discretion				
Alabama	No	Yes	Yes	No	No	Yes	Yes	No	No	No
Alaska	No	No	No	No	No	No	No	No	No	No
Arizona	No	No	No	No	No	No	No	No	No	No
Arkansas	No	No	No	No	No	Yes	No	No	No	No
California	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Colorado	No	Yes	No	Yes	No	Yes	No	No	No	Yes
Connecticut	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Delaware	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes
Florida	No	Yes	Yes	No	No	No	No	No	No	No
Georgia	No	No	Yes	No	No	No	No	No	No	Yes
Hawaii	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Idaho	No	No	No	No	No	No	No	No	No	No
Illinois	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Indiana	No	Yes	Yes	No	No	Yes	No	No	No	No
Iowa	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No
Kansas	No	No	No	No	No	No	No	No	No	No
Kentucky	No	No	No	No	No	No	No	No	No	No
Louisiana	No	No	No	No	No	No	No	No	No	No
Maine	No	No	No	No	No	Yes	No	No	No	Yes
Maryland	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes
Massachusetts	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Michigan	No	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes
Minnesota	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes
Mississippi	No	No	No	No	No	No	No	No	No	Yes
Missouri	No	No	No	No	No	Yes	No	No	No	No
Montana	No	No	No	No	No	Yes	No	No	No	No
Nebraska	No	Yes	Yes	Yes	Yes	No	No	No	Yes	No
Nevada	No	No	No	No	No	No	No	No	No	No
New Hampshire	No	Yes	No	No	No	Yes	No	No	No	No
New Jersey	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
New Mexico	No	No	No	No	No	No	No	No	No	No
New York	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
North Carolina	Yes	No	Yes	Yes	Yes	No	No	No	No	Yes
North Dakota	No	Yes	No	No	No	No	Yes	No	No	No
Ohio	No	No	No	No	No	No	No	Yes	No	No
Oklahoma	No	No	No	No	No	No	No	No	No	No
Oregon	No	Yes	Yes	Yes	No	Yes	No	No	No	Yes
Pennsylvania	No	Yes	Yes	Yes	No	Yes	Yes	No	No	No
Rhode Island	No	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes
South Carolina	No	Yes	No	No	No	No	No	No	No	Yes
South Dakota	No	No	No	No	No	No	No	No	No	No
Tennessee	No	No	Yes	No	No	No	No	No	No	Yes
Texas	No	No	No	No	No	No	No	No	No	No
Utah	No	Yes	Yes	No	No	Yes	No	No	No	No
Vermont	No	No	No	No	No	No	No	No	No	Yes
Virginia	Yes	Yes	Yes	No	No	No	No	No	No	Yes
Washington	No	Yes	Yes	No	No	No	No	No	No	No
West Virginia	No	No	No	No	No	No	No	No	No	No
Wisconsin	No	Yes	Yes	No	No	Yes	No	No	No	No
Wyoming	No	No	No	No	No	Yes	No	No	No	Yes

Source: Mayors Against Illegal Guns (2010). See Table 2 for the definition of variable names in first row.



**TABLE A2**  
Poisson Regression Estimates for Interstate Crime Gun Exports with Matching Laws (associated with Table 4)

	Dependent Variable: $T_{ij}$
$\ln(GDP_i)$	0.902*** (0.0355)
$\ln(GDP_j)$	1.016*** (0.0286)
$\ln(GDP_i \text{ per capita})$	2.329*** (0.282)
$\ln(GDP_j \text{ per capita})$	-0.683*** (0.204)
$\ln(\text{distance}_{ij})$	-1.027*** (0.0463)
Contiguous	0.586*** (0.0732)
$\ln(\text{remote}_i)$	0.700*** (0.158)
$\ln(\text{remote}_j)$	0.812*** (0.143)
$Gang_i$	0.0287 (0.0507)
$Gang_j$	0.176*** (0.0617)
Police Expenditures <sub>i</sub>	0.121 (0.0889)
Police Expenditures <sub>j</sub>	0.0780 (0.0754)
Constant	-35.99*** (2.129)
Observations	2450
Pseudo- $R^2$	0.814

Notes: Robust standard errors in parentheses.

\*\*\*  $p < 0.01$ ; \*\*  $p < 0.05$ ; \*  $p < 0.1$ .

#### REFERENCES

- Anderson, J. E. "A Theoretical Foundation of the Gravity Equation." *American Economic Review*, 69, 1979, 106–16.
- Anderson, J. E., and E. van Wincoop. "Gravity with Gravititas: A Solution to the Border Puzzle." *American Economic Review*, 93, 2003, 170–92.
- Bergstrand, J. H. "The Gravity Equation in International Trade: Some Microeconomic Foundations and Empirical Evidence." *The Review of Economics and Statistics*, 67, 1985, 474–81.
- . "The Generalized Gravity Equation, Monopolistic Competition, and the Factor-Proportions Theory in International Trade." *The Review of Economics and Statistics*, 71, 1989, 143–53.
- Bureau of Alcohol, Tobacco and Firearms. *Following the Gun: Enforcing Federal Laws against Firearm Traffickers*. Washington, DC: Bureau of Alcohol, Tobacco and Firearms, 2000.
- Burger, M., F. van Oort, and G.-J. Linders. "On the Specification of the Gravity Model of Trade: Zeros, Excess Zeros and Zero-inflated Estimation." *Spatial Economic Analysis*, 4, 2009, 167–90.
- Cook, P. J., and J. Ludwig. *Guns in America*. Washington, DC: Police Foundation, 1996.
- . "Aiming for Evidenced-Based Gun Policy." *Journal of Policy Analysis and Management*, 25, 2006, 691–735.
- . "Five Myths about Gun Control." *Washington Post*. 2010. Accessed May 26, 2011. <http://www.washingtonpost.com/wp-dyn/content/article/2010/06/11/AR201061103259.html>.
- Cook, P. J., J. Ludwig, S. Venkatesh, and A. A. Braga. "Underground Gun Markets." *The Economic Journal*, 117, 2007, F558–88.
- Diamond, P. A. "Aggregate Demand Management in Search Equilibrium." *Journal of Political Economy*, 90, 1982, 881–94.
- Duggan, M. "More Guns, More Crime." *Journal of Political Economy*, 109, 2001, 1086–114.
- Feenstra, R. C., R. E. Lipsey, and H. P. Bowen. "World Trade Flows, 1970–1992, with Production and Tariff Data." Working Paper No. 5910, National Bureau of Economic Research, Cambridge, MA, 1997.
- Flowerdew, R., and M. Aitkin. "A Method of Fitting the Gravity Model Based on the Poisson Distribution." *Journal of Regional Science*, 22, 1982, 191–202.
- Frankel, J. A. *Regional Trading Blocs in the World Economic System*. Washington, DC: Institute for International Economics, 1997.
- Frankel, J., and A. Rose. "An Estimate of the Effect of Common Currencies on Trade and Income." *Quarterly Journal of Economics*, 117, 2002, 437–66.
- Knight, B. "State Gun Policy and Cross-State Externalities: Evidence from Crime Gun Tracing." Working Paper No. w17469, National Bureau of Economic Research, Cambridge, MA, 2011.
- Linders, G.-J. M., and H. L. F. de Groot. "Estimation of the Gravity Equation in the Presence of Zero Flow." Tinbergen Institute Discussion Paper, TI 2006–072/3, 2006.
- Lott, J. R. Jr. *More Guns, Less Crime: Understanding Crime and Gun Control Laws*. Chicago, IL: University of Chicago Press, 1998.
- Mayors Against Illegal Guns. "Trace the Guns: The Link Between Gun Laws and Interstate Gun Trafficking." 2010. Accessed May 24, 2011. [http://www.mayorsagainstillegalsguns.org/downloads/pdf/trace\\_the\\_guns\\_report.pdf](http://www.mayorsagainstillegalsguns.org/downloads/pdf/trace_the_guns_report.pdf).
- McCallum, J. "National Borders Matter: Canada–U.S. Regional Trade Patterns." *American Economic Review*, 85, 1995, 615–23.
- Michalski, T., and E. Ors. "(Inter-state) Banking and (Inter-state) Trade: Does Real Integration Follow Financial Integration?" CEPR Discussion Paper No. DP7963. 2010. [http://www.fdic.gov/bank/analytical/cfr/bank\\_research\\_conference/annual\\_10th/papers/ors.pdf](http://www.fdic.gov/bank/analytical/cfr/bank_research_conference/annual_10th/papers/ors.pdf).
- Raballand, G. "Determinants of the Negative Impact of Being Landlocked on Trade: An Empirical Investigation through the Central Asian Case." *Comparative Economic Studies*, 4, 2003, 520–36.
- Rose, A. K. "One Money, One Market: The Effect of Common Currencies on Trade." *Economic Policy*, 15, 2000, 7–45.
- . "Do We Really Know That the WTO Increases Trade?" *American Economic Review*, 94, 2004, 98–114.
- Santos Silva, J. C. M., and S. Tenreiro. "The Log of Gravity." *The Review of Economics and Statistics*, 88, 2006, 641–58.
- Tinbergen, J. *Shaping the World Economy. Suggestions for an International Economic Policy*. New York: The Twentieth Century Fund, 1962.
- Vernick, J. S., and L. M. Hepburn. "State and Federal Gun Laws: Trends for 1970–99," in *Evaluating Gun Policy: Effects on Crime and Violence*, edited by J. Ludwig and P. J. Cook. Washington, DC: Brookings Institution Press, 2003, 345–411.
- Wang, Z. K., and A. L. Winters. "The Trading Potential of Eastern Europe." CEPR Discussion Papers, No. 610, 1991.
- Wolf, H. "Intranational Home Bias in Trade." *Review of Economics and Statistics*, 82, 2000, 555–63.
- Wooldridge, J. M. *Introductory Econometrics: A Modern Approach*. 4th ed. Mason, OH: South Western, 2009.
- Yilmazkuday, H. "Understanding Interstate Trade Pattern." Available at SSRN: <http://ssrn.com/abstract=995542>, 2009.