The American Statistician

ISSN: 0003-1305 (Print) 1537-2731 (Online) Journal homepage: http://www.tandfonline.com/loi/utas20

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To cite this article: Daniel Cerqueira, Danilo Coelho, Marcelo Fernandes & Jony Pinto Junior (2018) Guns and Suicides, The American Statistician, 72:3, 289-294, DOI: 10.1080/00031305.2017.1419144

To link to this article: https://doi.org/10.1080/00031305.2017.1419144

Accepted author version posted online: 15 Jan 2018.
Published online: 04 Jun 2018.

THE AMERICAN STATISTICIAN
2018, VOL. 72, NO. 3, 289–294: Interdisciplinary
https://doi.org/10.1080/00031305.2017.1419144

Guns and Suicides

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ABSTRACT
There is a consensus in the literature that the ratio of suicides committed with guns to total suicides is the best indirect measure of gun ownership. However, such a proxy is not accurate for any locality with low population density in view that suicides are rare events. To circumvent this issue, we exploit the socioeconomic characteristics of the suicide victims in order to come up with a novel proxy for gun ownership. We assess our indicator using suicide micro-data from the Brazilian Ministry of Health between 2000 and 2010.

ARTICLE HISTORY
Received January 2017
Accepted December 2017

KEYWORDS
Crime; Firearm; Fixed effects; Logit; Panel data; Regularization; Violence

1. Introduction

The debate about causal effects of gun ownership on crime is intense (Hepburn and Hemenway 2004). If the presence of firearms increases the likelihood of conflict resolution by violence, then the number of homicides will increase with gun ownership. However, it may also entail a deterrent effect if criminals deem that the probability of a potential victim to have a firearm is large enough. As a result, the impact of gun prevalence in criminal activity is, in theory, ambiguous at best. The empirical results in the literature are mixed as well. Most papers conclude that gun prevalence cause violent crimes (see, among others, McDowall 1991; Cook and Ludwig 1998; Ludwig 1998; Stolzenberg and D'Alessio 2000; Duggan 2001), though a few studies advocate it deters (property) crimes (Lott and Mustard 1997; Bartley and Cohen 1998; Kleck 2015).

The main issue is data limitation. Governments do not usually maintain a registry of guns in private hands at the local level. Household surveys about gun ownership are rare and nonrepresentative. Researchers resort to indirect measures: proportion of burglaries or suicides using firearms (McDowall 1991); number of registered firearms (Cummings et al. 1997); number of licenses to carry firearms and of stolen guns as reported to the police (Stolzenberg and D'Alessio 2000); subscriptions to gun-oriented magazines and membership in the NRA (Duggan 2001; Moody and Marvell 2002); and proportion of suicides using a gun (Cook and Ludwig 2003; Azrael, Cook, and Miller 2004). The consensus posits the latter is the best proxy.

Kleck (2004) examined the validity of 25 proxy measures of gun availability at the city, state, and country levels from 1972 to 1999. The only proxy variable that correlates well with the percentage of households with at least one firearm taken from the General Social Survey is the proportion of suicides committed with a gun. See also Killias (1993) and Briggs and Tabarrok (2014) for similar evidence. This is reassuring because suicide data are readily available at the municipal level. However, the relative frequency of suicides committed with a gun converges to the probability of committing suicide with a gun only in large samples. Suicides are rare events, though; and so such a proxy yields a precise measure of relative gun availability only for highly-populated municipalities. There is indeed a lot of variation in the proportion of suicides committed with a gun for any municipality with only a few suicide cases, making inference about gun prevalence indeed very hard.

We propose a novel approach to estimate gun prevalence from suicide micro-data. We compute the probability of committing suicide with a gun given victim characteristics and micro-region fixed effects. Victim characteristics are very informative. For instance, women usually employ least violent means to commit suicide, such as drug and carbon monoxide poisoning (Denning et al. 2000). A large proportion of women using a gun to commit suicide then indicates wider gun availability.

We pool information from different micro-regions, increasing the precision of estimates. This is of particular importance for sparsely populated areas. Interestingly, we show that micro-region fixed effects should reflect gun prevalence under a very reasonable identification assumption. In particular, we require that the decision of using a gun to commit suicide conditional on the decision of committing suicide does not depend on any aggregate factor that varies only across micro-region other than gun prevalence. This means that quality of life affects the number of suicides with a gun only through the decision of taking his/her own life (and possibly through gun prevalence).

Using suicide micro-data from the Brazilian Ministry of Health between 2000 and 2010, we find that the micro-regions fixed effects correspond well to the spatial variation in gun prevalence in Brazil, conforming with some traditional (and very imperfect) indicators, such as the number of licenses to carry a firearm. In addition, our indicators of gun prevalence based on micro-region fixed effects entail significantly positive linear and nonlinear correlations with homicide rates. This is in sharp contrast with the traditional proxy, whose linear and nonlinear correlations with homicide rates exhibit opposite signs, even if statistically not different from zero.

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Color versions of one or more of the figures in the article can be found online at www.tandfonline.com/r/TAS.

In the next section, we discuss identification. Section 3 describes the Brazilian micro-data about suicides, whereas Section 4 discusses empirical findings. Section 5 offers some concluding remarks.

2. Identification

We start with the assumption that the individual decision of committing suicide depends on personal characteristics $\boldsymbol{X}_{ij}$ of the victim and on overall quality of life Q_j in micro-region j. Among other social stressors, quality of life includes exposure to violence, which is known to affect the state of mind of individuals, increasing depression and suicide risks (Mazza and Reynolds 1999; Flannery, Singer, and Wester 2001; Cornaglia, Feldman, and Leigh 2014). It also influences the decision of owning a gun and, accordingly, gun prevalence G_j in micro-region j depends not only on population composition ($\boldsymbol{X}_j = \sum_i \boldsymbol{X}_{ij}$), but also on quality of life. This implies

$$\Pr(S_{ij}, G_j|\boldsymbol{X}_{ij}, Q_j) = \Pr(S_{ij}|\boldsymbol{X}_{ij}, Q_j)\Pr(G_j|\boldsymbol{X}_j, Q_j), \quad (1)$$

with S_{ij} taking value one if individual i in micro-region j decides to commit suicide, zero otherwise. We implicitly assume that the decision of individual i to commit suicide does not affect the decision of individual i' after conditioning on personal characteristics and quality of life.

We next restrict attention to a sample of suicide victims and let SwG_{ij} assume value one if victim i in micro-region j commits suicide using a gun, zero otherwise. We assume that the decision about the suicide method depends on quality of life only through the decisions of committing suicide and of owning a gun:

$$\Pr(SwG_{ij}|S_{ij}=1, \boldsymbol{X}_{ij}, G_j, Q_j) = \Pr(SwG_{ij}|S_{ij}=1, \boldsymbol{X}_{ij}, G_j). \quad (2)$$

Once we estimate the probability in (2) using suicide micro-data, we can back out $\widehat{G}_j$ from the micro-region fixed effects. Standard asymptotic theory ensures that $\widehat{G}_j$ converges in probability to G_j, as the number of suicides in micro-region j grows.

We estimate (2) using a logit specification:

$$\Pr(SwG_{ij}|S_{ij}=1, \boldsymbol{X}_{ij}, G_j) = \frac{\exp\left(\boldsymbol{X}_{ij}\boldsymbol{\beta} + \sum_{j=1}^{J} G_j D_{ij}\right)}{1+\exp\left(\boldsymbol{X}_{ij}\boldsymbol{\beta} + \sum_{j=1}^{J} G_j D_{ij}\right)}, \quad (3)$$

where D_{ij} is a dummy variable that takes value one if suicide victim i belongs to micro-region j (with $j = 1, \ldots, J$), zero otherwise. We estimate (3) using standard panel regression methods for generalized linear models (GLM) and then proxy gun prevalence by $\widehat{G}_j$.

The presence of many insignificant micro-region fixed effects might distort the ranking of gun prevalence across micro-regions. Sorting by t-statistics does not help. First, spatial heterogeneity clearly affects the magnitude of the standard errors and hence focusing on t-statistics biases our proxy of gun prevalence in small micro-regions toward zero. Second, t-statistics exhibit discontinuity at zero for the sign of the estimates uniquely determines its sign regardless of significance.

We check whether insignificant fixed effects matters using shrinkage. We also estimate the micro-region fixed effects in (3) using regularization techniques (Bühlmann and van de Geer 2011). We constrain the objective function by capping the sum of the fixed-effect absolute values. This essentially shrinks fixed effects toward zero, keeping only the most relevant estimates. More specifically, we maximize

$$\ell_\lambda(\boldsymbol{\beta}, \boldsymbol{G}) = \ell(\boldsymbol{\beta}, \boldsymbol{G}) - \lambda \sum_{j=1}^{J} w_j |G_j|, \quad (4)$$

where $\ell(\boldsymbol{\beta}, \boldsymbol{G})$ is the log-likelihood function.

The standard GLM estimator coincides with (4) in case $w_j = 0$ for every $j = 1, \ldots, J$. Tibshirani (1996) least absolute shrinkage and selection operator (LASSO) ensues with uniform weights ($w_j = 1$ for $j = 1, \ldots, J$), whereas Zou (2006) adaptive penalization (adaLASSO) employed $w_j = |1/\widehat{G}_j|$ for a consistent initial estimate $\widehat{G}_j$ of G_j (in this case, GLM). The advantage of adaLASSO is that it almost surely eliminates irrelevant fixed effects under weaker conditions than LASSO.[1] As the sample size grows, coefficient estimates converge to their true values. This means that weights for nonzero coefficients converge to nonzero constants, whereas weights for zero coefficients diverge. It is paramount to select λ very carefully. Too much shrinkage might end up selecting out relevant regressors, whereas too little might keep redundant fixed effects. As in Tibshirani (1996) and Zou (2006), we choose λ by cross-validation.

Table 1. Descriptive statistics for the number of suicides from 2000 to 2010.

Number of suicides	Mean	Minimum	First quartile	Median	Third quartile	Maximum
Using a gun	23.91	0	5	11	23	828
Total	165.40	0	44	82	165	5,932

We report mean, minimum, and maximum values for the number of suicides across the 558 micro-regions in Brazil as well as their empirical quartiles from 2000 to 2010.

3. Data Description

We employ data from the Mortality Information System of the Brazilian Ministry of Health. It provides information about every suicide from 2000 to 2010 at the micro-region level,[2] including victim's age, gender, race, marital status, and years of schooling. Table 1 summarizes the number of suicide victims across the 558 micro-regions. The huge dispersion reflects the immense difference in population size across micro-regions in Brazil.

Table 2 describes the distribution of personal characteristics of the suicide victims in our sample. The vast majority of victims are male: 79% in the overall sample and 88% of suicides using a gun. The average age of a suicide victim is about 40 years old. The corresponding figure for the subsample of suicides committed with a gun is slightly less, even if marginally more concentrated in ages above the minimum legal age to carry a gun. The fraction of white victims is about 55%, but increases to almost

1 Although we shrink only fixed effects, one could also regularize other coefficients (see Koch 2014).

2 The definition of micro-region is from the Brazilian Institute of Geography and Statistics (IBGE), consisting of homogeneous groups of neighboring municipalities with similar socio-economic and natural characteristics. IBGE pays particular attention to the production structures of each municipality and to the spatial interaction and communication between them in order to cluster the 5570 municipalities in Brazil into 558 micro-regions and then into 137 meso-regions.

Table 2. Personal characteristics of the suicide victims.

Characteristics		Suicide victim using a gun	Total
Age		39.08	40.05
Legal age to own a firearm		0.87	0.86
Occupation with legal access to guns		0.16	0.13
Gender	Male	0.88	0.79
	Female	0.12	0.21
Race/skin color	White	0.65	0.55
	Black	0.04	0.05
	East Asian	0.004	0.005
	Mixed	0.26	0.33
	Amerindians	0.002	0.009
	Unreported	0.04	0.06
Marital status	Single	0.47	0.49
	Civil union	0.02	0.01
	Married	0.35	0.33
	Widower	0.03	0.04
	Divorced	0.07	0.05
	Unreported	0.06	0.07
Schooling	None	0.03	0.06
	1 to 3 years	0.13	0.16
	4 to 7 years	0.20	0.21
	8 to 11 years	0.15	0.12
	12+ years	0.10	0.06
	Unreported	0.39	0.39

We report mean values for age of the victim in years as well as for some personal characteristic indicators that take value one if true, zero otherwise. The sample period runs from 2000 to 2010, with a change in the minimum legal age to own a gun from 21 to 25 years old in December 2003.

2/3 if using a gun, reflecting the relative higher income of white individuals in Brazil. The same applies to years of schooling, which also strongly correlates with income.

4. Probability of Committing Suicide with a Gun

Table 3 displays the coefficient estimates of the panel logit model for the probability of using a gun to commit suicide. Apart from micro-region fixed effects, we control for age, squared age, and several dummy variables relating to categorical features: ethnicity, gender, marital status, years of schooling, minimum legal age to own a gun, and occupation with legal access to firearms. It is perhaps worth stressing that the qualitative results are very similar if we pool data into meso-regions rather than micro-regions. Meso-region fixed effects are indeed very close to the average micro-region fixed effects of their constituents. All results are available upon request.

The probability of committing a suicide with a gun decreases with age up to the legal age to own a gun,[3] at which point it jumps up before decreasing again. Also, suicide victims that have legal access to firearms because of their line of work are much more likely to use a gun to take their own lives. Gender and race also entail profound impact given that white males are by far the vast majority of gun suicide victims. Single suicide victims are less likely to use a firearm than individuals who had a stable partner at some point. Finally, the more years in school, the higher the odds of using a firearm (expensive, but less likely to fail).

Figure 1 illustrates how our indirect measures compare with the proportion of suicides using guns. Rank correlation is very high for any pair of gun prevalence indicators, though higher

[3] The legal age was 21 years old, but it changed to 25 years old after the gun control act of December 2003.

Table 3. Panel logit regression with micro-region fixed effects for the probability of using a gun to commit suicide.

Controls		Standard panel GLM	(Standard Error)	LASSO	adaLASSO
Age		− 0.01542	(0.0010)	− 0.09225	− 0.09218
Squared age		0.00002	(1.73E-06)	0.00080	0.00080
Legal age to own a firearm		0.14750	(0.0330)	0.38164	0.38189
Occupation with legal access to guns		0.60660	(0.0280)	0.52238	0.52341
Gender	Female	− 1.03300	(0.0301)	− 1.04049	− 1.04151
Race/skin color	Black	− 0.55700	(0.0508)	− 0.58633	− 0.58769
	East Asian	− 0.29450	(0.1567)	− 0.40519	− 0.40370
	Mixed	− 0.40520	(0.0277)	− 0.43739	− 0.43884
	Amerindians	− 1.75500	(0.2094)	− 2.00908	− 2.01156
	Unreported	− 0.27020	(0.0520)	− 0.34954	− 0.34775
Marital status	Civil union	0.49370	(0.0740)	0.57708	0.57459
	Married	0.29500	(0.0260)	0.44048	0.44040
	Widower	0.19690	(0.0602)	0.08210	0.08194
	Divorced	0.35210	(0.0436)	0.54722	0.54729
	Unreported	0.00436	(0.0447)	0.07324	0.07282
Schooling	1–3 years	0.29060	(0.0587)	− 0.10802	− 0.10535
	4–7 years	0.40780	(0.0579)	− 0.01381	− 0.01117
	8–11 years	0.75730	(0.0603)	0.31327	0.31661
	12+ years	1.13300	(0.0644)	0.72259	0.72615
	Unreported	0.53560	(0.0571)	0.09500	0.09965

The dataset from the Brazilian Ministry of Health includes all suicides across the 558 micro-regions in Brazil from 2000 to 2010. We report standard GLM coefficient estimates and their robust standard errors, as well as the corresponding LASSO and adaLASSO estimates that shrink micro-region fixed effects. Note that the minimum legal age to own a gun changes from 21 years old to 25 years old in December 2003.

among fixed-effect estimates. Neither the presence of insignificant micro-region fixed effects nor the choice of regularization method affect much gun prevalence rankings. In addition, regularization seems to yield smoother color-coded maps, with adjacent micro-regions exhibiting more similar colors. Gun prevalence is strong in the borders with Bolivia, Peru, and Paraguay. The vastness of the Brazilian borders make them vulnerable. Organized crime run illicit drugs and firearms trafficking through Brazil, bringing forth more violence in transit zones (Mora 1996; Stohl and Tuttle 2008). Gun availability is also high in the Amazon, where conflicts are common because of natural-resource exploitation and illegal timber trading (Aston, Libecap, and Mueller 1999, 2000; Hotte 2001; Chimeli and Soares 2015).

Table 4 documents that rankings are also very similar for state capitals. They agree that Campo Grande, Cuiabá, Porto Alegre and Porto Nacional are the state capitals with the highest prevalence of firearms as well as that Belém, Fortaleza, Macapá, and Manaus have the lowest. There are some disagreements, though. The traditional proxy indicates that gun prevalence in Curitiba is slightly higher than in Brasília, with a proportion of gun suicides of 17.9% (against 17.3%). However, fixed effects unanimously rank Brasília above Curitiba: −1.52 (or 0.19 if we employ shrinkage) against −1.72 (or 0 if we regularize). The usual proxy fails to spot the difference because it ignores victim characteristics. The main distinction here is race. Curitiba is a Southern city, with a predominant white population descending from European immigrants (notably, German, Polish, Italian, and Ucranian), whereas nonwhite individuals prevail in Brasília. Because white victims use more guns than nonwhites, fixed effects indicate more firearms in Brasília.

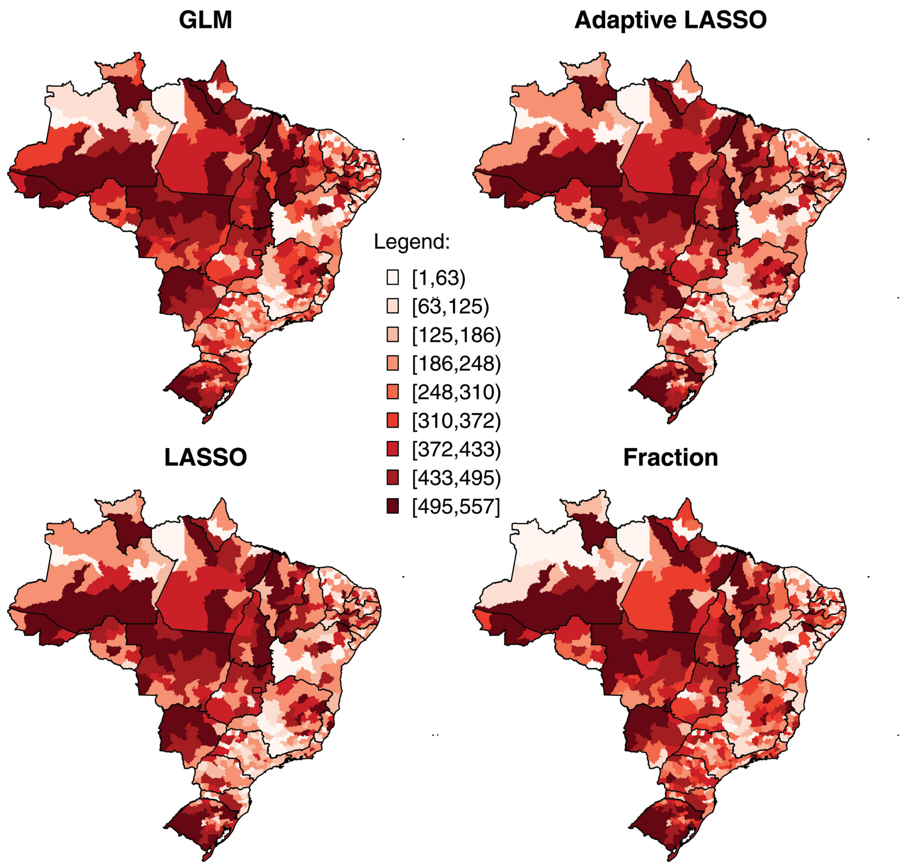

Figure 1. Ranking micro-regions from least (in white) to most (in dark red) gun prevalence. The first plot offers a ranking based on GLM panel estimates of the micro-region fixed effects. The second and third plots map rankings based on regularized micro-region fixed effect estimates. The last map ranks micro-regions by the ratio of suicides committed with guns to total suicides.

Table 4. Gun prevalence across state capitals.

Micro-region	State	Number of suicides	Fraction		GLM		LASSO		adaLASSO	
Porto Alegre	RS	2,694	0.24	(1)	− 1.27	(4)	0.48	(1)	0.48	(1)
Campo Grande	MS	468	0.23	(2)	− 1.20	(1)	0.47	(2)	0.47	(2)
Cuiabá	MT	369	0.20	(3)	− 1.20	(1)	0.46	(3)	0.46	(3)
Porto Nacional	TO	177	0.20	(3)	− 1.21	(3)	0.39	(4)	0.40	(4)
Porto Velho	RO	244	0.17	(7)	− 1.38	(6)	0.21	(5)	0.22	(5)
Rio Branco	AC	226	0.19	(5)	− 1.36	(5)	0.19	(6)	0.19	(6)
Brasília	DF	1,276	0.17	(7)	− 1.52	(8)	0.19	(6)	0.19	(6)
Goiânia	GO	1,335	0.17	(7)	− 1.56	(9)	0.17	(8)	0.17	(8)
João Pessoa	PB	358	0.15	(10)	− 1.51	(7)	0.14	(9)	0.15	(9)
Natal	RN	275	0.13	(13)	− 1.73	(11)	0	(10)	0	(10)
Aracaju	SE	498	0.12	(16)	− 1.81	(12)	0	(10)	0	(10)
Curitiba	PR	1,514	0.18	(6)	− 1.72	(10)	0	(10)	0	(10)
Vitória	ES	656	0.12	(16)	− 1.87	(15)	0	(10)	0	(10)
Belo Horizente	MG	2,209	0.14	(11)	− 1.82	(13)	0	(10)	0	(10)
Recife	PE	1,203	0.11	(18)	− 1.85	(14)	0	(10)	− 0.01	(15)
Boa Vista	RR	218	0.10	(20)	− 1.96	(17)	− 0.08	(16)	− 0.09	(16)
Teresina	PI	674	0.11	(18)	− 1.91	(16)	− 0.12	(17)	− 0.13	(17)
Rio de Janeiro	RJ	2,842	0.13	(13)	− 1.97	(18)	− 0.14	(18)	− 0.15	(18)
Salvador	BA	535	0.09	(21)	− 2.10	(20)	− 0.17	(19)	− 0.18	(19)
São Paulo	SP	5,932	0.14	(11)	− 1.98	(19)	− 0.18	(20)	− 0.19	(20)
Florianópolis	SC	491	0.13	(13)	− 2.15	(21)	− 0.28	(21)	− 0.29	(21)
Maceió	AL	395	0.08	(24)	− 2.21	(23)	− 0.28	(21)	− 0.29	(21)
São Luís	MA	425	0.09	(21)	− 2.20	(22)	− 0.32	(23)	− 0.34	(23)
Manaus	AM	775	0.09	(21)	− 2.21	(23)	− 0.40	(24)	− 0.41	(24)
Belém	PA	554	0.08	(24)	− 2.29	(25)	− 0.42	(25)	− 0.43	(25)
Fortaleza	CE	2,008	0.06	(26)	− 2.56	(26)	− 0.69	(26)	− 0.70	(26)
Macapá	AP	284	0.06	(26)	− 2.75	(27)	− 0.84	(27)	− 0.86	(27)

We report the number of suicides and gun prevalence indicators in the micro-regions that surround a state capital, based on data from the Brazilian Ministry of Health. We proxy for gun prevalence either using the proportion of suicides committed with a gun ("fraction") or the standard GLM, LASSO, and adaLASSO estimates of the micro-region fixed effects in the logit regression. Figures within parentheses refer to the corresponding ranking of gun prevalence.

Table 5. The micro-regions in Brazil with the highest gun prevalence.

Micro-region	State	# Suicides	Fraction		GLM		LASSO		adaLASSO	
Madeira	AM	17	0.59	(1)	0.67	(1)	2.07	(1)	2.09	(1)
Boca do Acre	AM	11	0.45	(2)	0.39	(2)	1.75	(2)	1.77	(2)
São Félix do Xingu	PA	45	0.38	(8)	− 0.02	(5)	1.54	(3)	1.56	(3)
Purus	AM	7	0.43	(3)	0.28	(3)	1.43	(4)	1.47	(4)
Jalapão	TO	25	0.36	(11)	− 0.05	(6)	1.37	(5)	1.39	(5)
Sena Madureira	AC	10	0.40	(4)	0.01	(4)	1.28	(6)	1.31	(6)
Juruá	AM	23	0.39	(5)	− 0.22	(7)	1.25	(7)	1.27	(7)
Baixo Pantanal	MS	49	0.35	(13)	− 0.32	(11)	1.25	(7)	1.26	(8)
Guamá	PA	54	0.33	(15)	− 0.31	(10)	1.24	(9)	1.26	(8)
Grão Mogol	MG	13	0.38	(8)	− 0.29	(9)	1.23	(10)	1.25	(10)
Campanha Ocidental	RS	398	0.38	(8)	− 0.47	(15)	1.22	(11)	1.22	(11)
Campanha Meridional	RS	160	0.39	(5)	− 0.47	(15)	1.18	(12)	1.18	(12)
Carira	SE	11	0.36	(11)	− 0.34	(13)	1.13	(13)	1.16	(13)
Gurupi	MA	27	0.30	(18)	− 0.33	(12)	1.11	(14)	1.13	(14)
Tarauacá	AC	33	0.33	(15)	− 0.23	(8)	1.09	(15)	1.10	(15)
Campanha Central	RS	235	0.35	(13)	− 0.64	(20)	1.03	(16)	1.03	(16)
Brasiléia	AC	14	0.36	(11)	− 0.37	(14)	1.01	(17)	1.03	(16)
Conceição do Mato Dentro	MG	37	0.30	(18)	− 0.58	(17)	0.96	(18)	0.98	(18)
Jaguarão	RS	63	0.32	(17)	− 0.64	(19)	0.96	(18)	0.97	(19)
Caracaraí	RO	25	0.28	(20)	− 0.63	(18)	0.90	(20)	0.92	(20)

We report the number of suicides in the 20 micro-regions with the highest fixed effects, based on the Brazilian Ministry of Health data from 2000 to 2010. Figures within parentheses refer to the corresponding ranking of gun prevalence.

The same reasoning explains the differences between São Feliz do Xingu and Campanha Ocidental, or between Guamá and Jaguarão, among the 20 micro-regions with largest gun prevalence (see Table 5). The first micro-region in both pairs is from Pará, whereas the second is from Rio Grande do Sul. Although both micro-regions in each pair exhibit the same very high proportion of gun suicides, our proxy indicates higher gun prevalence in the micro-regions from the state of Pará because most victims are nonwhite individuals as opposed to a vast majority of white victims in Rio Grande do Sul. More interestingly perhaps, Figure 1 shows very clearly that the color of the micro-regions in Northern Amazonas becomes darker as we move from the traditional proxy to the proxy based on fixed effects, especially for the regularized versions. This happens essentially because the vast majority of gun suicide victims in these micro-regions are single, relatively young, and not in a profession that grants license to carry a firearm. For instance, the typical gun suicide victim in Rio Negro is 34.4 years old (against 42.7 for suicide victims using or not a gun) and single. In addition, there is no gun suicide victim with the right to carry a gun due to his profession.

It is obviously very hard to assess how much we gain in precision by using our gun prevalence estimates. We nonetheless report in Table 6 measures of association between gun prevalence and homicide rates. The aim is not to put perspective on the somewhat mixed evidence in the literature on whether gun availability increases or reduces crime given that correlation does not imply causality. However, both indicators should point to the same direction if unbiased. In addition, if our proxy is indeed more precise, it should entail correlation measures with lower standard errors.

Linear correlation is not statistically different from zero regardless of the proxy we use, despite their opposite signs: −0.0210 with a p-value of 0.6210 for the traditional proxy and 0.0278 with a p-value of 0.5117 for our gun prevalence indicator based on micro-region fixed effects. The picture changes dramatically if we move to nonlinear measures of association. Spearman's rank correlations are positive for both gun prevalence proxies, though significant only for our proxy: 0.0243 with a p-value of 0.5662 against 0.1002 with a p-value of 0.0180. The same happens if we focus on the number of concordances and discordances given that Kendall's correlation measures are equal to 0.0173 with a p-value of 0.5418 for the traditional proxy and 0.0661 with a p-value of 0.0200 for our proxy. Regularization makes the pattern even stronger. Linear correlation becomes significantly positive at the 10% level, whereas the other measures of association also increase substantially.

Table 6. Measures of association between gun prevalence and homicide rates.

		Micro-region fixed effects		
	Traditional proxy	GLM	LASSO	adaLASSO
Pearson's linear correlation	− 0.0210	0.0279	0.0720	0.0716
	(0.6210)	(0.5117)	(0.0895)	(0.0913)
Spearman's rank correlation	0.0244	0.1002	0.1473	0.1354
	(0.5662)	(0.0180)	(0.0005)	(0.0014)
Kendall's correlation	0.0173	0.0661	0.1025	0.0930
	(0.5418)	(0.0200)	(0.0005)	(0.0014)

We report linear, rank, and Kendall's correlation with homicide rates across micro-regions in Brazil for the traditional proxy of gun prevalence as well as for our micro-region fixed effects as estimated by GLM, LASSO, and adaLASSO. We also display in parentheses the p-values of a two-sided test for the null hypothesis that the correlation measure is zero.

5. Conclusion

There is seemingly a consensus that the proportion of suicides using a gun is the best proxy for gun availability in the literature. We propose a panel logit approach that accounts for the socioeconomic characteristics of the suicide victim in order to improve the precision of such indirect measure of gun prevalence. This is especially relevant for areas with low population density. We empirically assess our new indicator of gun availability using suicide data from the Brazilian Ministry of Health between 2000 and 2010. The results are very promising in that conditioning on the personal characteristics of the victim brings about a lot of relevant information.

We have two applications in mind as what concerns future research. First, it would be interesting to assess whether the results in Cerqueira and de Mello (2013) still hold once we proxy gun prevalence by our micro-region fixed effects rather than the proportion of suicides with a gun. In particular, they exploit the exogenous variation given by the federal anti-firearm legislation enacted in December 2003 to conclude that decreasing gun prevalence by one standard deviation reduces the number of homicides by one quarter of a standard deviation. Our preliminary correlation analysis seems to confirm the positive relationship between homicide rates and gun prevalence, though at this point we cannot talk about causality.

Second, we could apply a similar methodology to uncover the prevalence of contraceptive means for woman. As in the case of gun prevalence, it is hard to come up with a neat proxy at the local level. We plan to exploit panel data from the Brazilian Ministry of Health on rape notifications to this end. As long as the prevalence of contraceptives does not affect the victim's decision to report a sexual crime, micro-region fixed effects in a logit regression for the probability of becoming pregnant after a rape given victim/agressor characteristics should reflect reasonably well the lack of contraceptive means in the micro-region.

Acknowledgments

We thank Dani Gamerman, Duda Mendes, Aureo de Paula, Vladimir Ponczek, Rodrigo Soares, Andrea Tesei, and Rodrigo Zeidan for helpful discussions as well as seminar participants at Queen Mary, ANPEC 2013, and ESTE 2015 for their valuable comments. Coelho and Fernandes thank financial support from CNPq (302272/2014-3). We bear full responsibility for any errors.

Funding

Conselho Nacional de Desenvolvimento Científico e Tecnológico [302272/2014-3].

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