Pigouvian Gun Taxation

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Abstract:

Despite increasing rates of gun violence in the United States in recent years, few estimates of the marginal social cost of guns have been undertaken, and the use of Pigouvian taxation to induce the internalization of negative externalities from firearms has rarely been discussed. This study presents new estimates of the size and growth of the stock of guns and the average price of firearms in the market, and then estimates their marginal external costs. The analysis indicates that for every million units added to the gun stock, there are about 60 additional firearm-related deaths. The marginal external cost per gun is conservatively estimated to be between $432 and $540, with efficiency requiring a Pigouvian tax of about 45 to 56 percent of the retail price. Existing taxes on firearms erode more than $1 billion per year in deadweight loss, but fail to fully induce internalization of the negative externalities of guns.

Keywords: Pigouvian taxation, negative externalities, marginal social cost, firearm-related deaths, guns.

JEL codes: D04, H23, L64, I31

I. Introduction

American society has experienced increasing levels of gun violence in recent years. Over the first two decades of this century, firearm-related deaths alone increased by more than 50 percent, exceeding 45,000 mortalities in 2020 (National Safety Council, 2024). As the leading cause of death among children and teenagers (McGough, *et al*., 2023), gun violence has been declared a public health crisis by the American Medical Association (Leonard, 2016), the American Public Health Association (2021), and the U.S. Surgeon General (2024), among others. In public

opinion polls, gun violence ranks among the nation's top concerns (Pew Research Center, 2023; Maher, 2024; Ad Council, 2024). Recent estimates of the total annual cost to society from gun violence range from $280 billion (Pereira, 2021) and $300 billion (Smith, 2016) at the low end, to $491.46 billion (CDC, 2020), $493.2 billion (Miller, *et al*., 2024), and $557 billion (Everytown Research & Policy, 2022) at the high end.

A traditional remedy for the negative external costs imposed on society by the sale of goods and services is Pigouvian taxation. The basic premise is that by raising the price paid by buyers and reducing the price received by sellers, the tax forces consumers and producers to internalize the costs that would otherwise be shifted to third parties. Yet, while Pigouvian taxes have long been applied to products such as alcohol, tobacco, and gasoline, the internalization of negative externalities from firearms has rarely been studied. Much of the discussion that has occurred concerns the legality of taxing products whose ownership is protected by the Second Amendment to the Constitution. The general (though not universal) consensus appears to be that Pigouvian gun taxes would be lawful, especially if the tax revenue was used to mitigate firearm-related harms (Shearer and Anderman, 2018; Salib, 2021; Griffith and Staudt, 2021).

The federal government currently assesses a Firearms and Ammunition Excise Tax (FAET) of 10 percent on handguns and 11 percent on long guns and ammunition; these rates have remained constant for seven decades, with exemptions for firearm parts, small producers, and production for military, police, educational, and personal use (Gravelle, 2023). Recent Congressional proposals, if enacted, would have raised the federal tax to 30 percent on all guns (Eisenhauer, 2025a), but those bills were never brought to a vote. While most states levy general sales taxes that apply to guns, only Pennsylvania, California, and Colorado assess excise taxes on gun sales—Pennsylvania at a flat $3 per gun, California at 11 percent since July 1, 2024

(Associated Press, 2023), and Colorado at 6.5 percent since April 1, 2025 (McCleary, 2024).[1] At the local level, Cook County, Illinois (encompassing Chicago), Tacoma, and Seattle assess excise taxes on firearms (Brownlee, 2024). Although none of these taxes appear to have resulted from an explicit analysis of social costs, their existence nevertheless induces some internalization of externalities. The extent to which they do so, however, has not previously been determined.[2]

The present paper attempts to measure the marginal external cost of firearms in the U.S., the deadweight loss resulting from their overproduction, the extent to which current taxes correct the inefficiency, and the Pigouvian tax rate that would induce buyers and sellers to fully internalize the negative externalities. The next section outlines the basic model, and the empirical implementation follows. After providing estimates of the stock and flow of firearms as well as their average prices and tax rates, we estimate the marginal external costs of guns. We then use the results to estimate the deadweight loss at equilibrium, the deadweight loss with existing taxes, and the tax rate that would eliminate the deadweight loss. Several limitations are discussed in the conclusion.

II. Model

Consider the basic model of Pigouvian taxation in Figure 1. Social cost is defined as the sum of private costs, including those from the production and distribution of output, and the external costs that are imposed on third parties outside the buy-sell transaction. Thus, for each additional unit of output, marginal social cost (MSC) is equal to marginal external cost (MEC) plus marginal private cost (MPC), the latter of which is captured by the market supply curve.

[1] Other states, including Maryland, Massachusetts, New Mexico, New York, Vermont, and Washington, have considered, but not yet enacted, special excise taxes on guns (Brownlee, 2024).
[2] As noted below, flat taxes, such as Pennsylvania's $3 per gun or Seattle's $25 per gun, lose value over time due to inflation. We focus here on *ad valorem* taxes, including the federal FAET and state and local general sales taxes.

Marginal benefits (MB) are assumed to accrue privately, and are reflected in the market demand curve (Bonner, 2022; Nesheva-Kiosseva, 2023). In the absence of any taxes, the market would achieve an equilibrium at Q_0, where MB = MPC, but society incurs a deadweight loss because social costs exceed benefits (MSC > MB). Existing taxes, including the federal FAET as well as state and local sales taxes that apply to guns, reduce output to Q_1, which diminishes the deadweight loss. A Pigouvian tax equal to the marginal external cost per gun would further reduce output to Q_2 and eliminate the deadweight loss entirely, resulting in a state of market efficiency (MSC = MB). On the other hand, if the tax rate was set too high, then it would create a new deadweight loss by inducing underproduction such that $Q < Q_2$ and MB > MSC.

[Figure 1 here]

To formalize the model and facilitate its empirical estimation, we assume isoelastic MB and MPC curves given by

$$MB = P^D = aQ^{-\alpha} \tag{1}$$

and

$$MPC = P^S = bQ^{\gamma} \tag{2}$$

respectively, where Q is the quantity of output, P^D is the price buyers pay, P^S is the price sellers receive, $a > 0$, and $b > 0$. The price elasticity of demand is $\varepsilon^D = (\partial Q/Q)/(\partial P^D/P^D) = -1/\alpha$ and the price elasticity of supply is $\varepsilon^S = (\partial Q/Q)/(\partial P^S/P^S) = 1/\gamma$. For any tax rate of $\tau \geq 0$,

$$P^D = (1+\tau)P^S\,, \tag{3}$$

and the quantity of output transacted in the marketplace is

$$Q = [a/b(1+\tau)]^{\frac{1}{(\alpha+\gamma)}}\,. \tag{4}$$

The buyer's share of any tax burden is $B^D = \alpha/(\alpha+\gamma)$ and the seller's share is $B^S = \gamma/(\alpha+\gamma)$.[3]

Using subscripts to denote the state of the market as depicted in Figure 1, the untaxed equilibrium state is 0, the current state is 1, and 2 denotes the state with a Pigouvian tax. Thus, with $\tau_0 = 0$, the market would achieve equilibrium at an output of

$$Q_0 = [a/b]^{\frac{1}{(\alpha+\gamma)}} \tag{5}$$

and an equilibrium price of

$$P_0 = b[a/b]^{\frac{\gamma}{(\alpha+\gamma)}} . \tag{6}$$

Neither Q_0 nor P_0 is directly observable, but we can retrieve both of these from known values. Note that with a tax rate of τ_1, the market produces

$$Q_1 = [a/b(1+\tau_1)]^{\frac{1}{(\alpha+\gamma)}} , \tag{7}$$

and the seller's price at Q_1 is

$$P_1^S = b[a/b(1+\tau_1)]^{\frac{\gamma}{(\alpha+\gamma)}} . \tag{8}$$

Dividing (7) by (5) and rearranging, we get

$$Q_0 = Q_1/\,[1/(1+\tau_1)]^{\frac{1}{(\alpha+\gamma)}} . \tag{9}$$

Likewise, dividing (8) by (6) and rearranging yields

$$P_0 = P_1^S/\,[1/(1+\tau_1)]^{\frac{\gamma}{(\alpha+\gamma)}} . \tag{10}$$

Thus, empirical knowledge of the price elasticities (and hence, α and γ), as well as current output (Q_1), the current retail price (P_1^S), and the existing tax rate (τ_1) will allow us to recover the

[3] By definition, $B^D/B^S = (P_1^D - P_0)/(P_0 - P_1^S) = \varepsilon^S/(-\varepsilon^D)$. Then using $B^D = 1 - B^S$ gives $B^S = -\varepsilon^D/(-\varepsilon^D + \varepsilon^S)$, and replacing $-\varepsilon^D$ and ε^S by $1/\alpha$ and $1/\gamma$ respectively gives the result.

equilibrium values. Once Q_0 and P_0 are known, the parameters a and b can be determined from (5) and (6) as

$$a = (Q_0)^{\alpha} P_0 \tag{11}$$

and

$$b = P_0/(Q_0)^{\gamma} . \tag{12}$$

We will assume that MSC is proportional to MPC, such that for any level of output, $\text{MSC} = \lambda\text{MPC}$ and thus $\text{MEC} = (\lambda - 1)\text{MPC}$, where $\lambda > 1$ and λ is constant across all states of the market. Empirically, we will estimate λ at the current market position, Q_1, as

$$\lambda = (MEC_1/MPC_1) + 1. \tag{13}$$

Then Q_2 occurs where MSC = MB; that is, where $\lambda b Q^{\gamma} = aQ^{-\alpha}$, so we have

$$Q_2 = [a/\lambda b]^{\frac{1}{(\alpha+\gamma)}} . \tag{14}$$

The original deadweight loss from externalities is the area between MSC and MB, from the equilibrium at Q_0 down to the efficient state at Q_2; that is

$$DWL_0 = \int_{Q_2}^{Q_0} (\lambda b Q^{\gamma} - aQ^{-\alpha})\, dQ . \tag{15}$$

However, because some taxes are already in place, the current market position is Q_1, and a portion of the deadweight loss has already been eroded; the remaining deadweight loss is

$$DWL_1 = \int_{Q_2}^{Q_1} (\lambda b Q^{\gamma} - aQ^{-\alpha})\, dQ , \tag{16}$$

and the effect of current taxes on efficiency is simply the difference between DWL_0 and DWL_1. Finally, the Pigouvian tax rate that sets $MSC_2 = MB_2$ and thus eliminates deadweight loss is

$$\tau_2 = MEC_2/MPC_2 = \lambda - 1, \tag{17}$$

and the tax revenue (TR_2) generated by the Pigouvian tax is equal to $\tau_2 P_2^S Q_2$, which is calculated as

$$TR_2 = \tau_2 b \left[\frac{a}{\lambda b}\right]^{\frac{1+\gamma}{\alpha+\gamma}}. \quad (18)$$

The following section attempts to estimate each of these values empirically, beginning with the actual state of the market at Q_1, P_1^S (or equivalently, MPC_1), τ_1, and P_1^D. We then turn to counterfactuals, quantifying the equilibrium output (Q_0) and price (P_0). Finally, we estimate the marginal external cost per firearm (MEC_1), the output that would occur in a state of market efficiency (Q_2), the deadweight losses that occur at Q_0 and Q_1, and the Pigouvian tax rate that would eliminate them.

III. Empirical Implementation

Gun Stocks and Flows

Accurate data on the stock of guns in the U.S. are difficult to obtain.[4] Several surveys have simply asked samples of individuals about their gun ownership, and then extrapolated from the respondents to the population. Unfortunately, surveys can only recruit a small fraction of the U.S. population at best, and nonresponse rates reduce sample sizes further, so that the results have tended to be inconsistent and imprecise, often giving extremely wide ranges. For example, with a response rate of less than 19 percent and a sample of 2,770, Hepburn, *et al*. (2007) estimated that 26 percent of adults owned guns in 2004, with the gun stock ranging from 260 million to 305 million guns. A decade later, with a sample of 3,949 individuals, Azrael, *et al*. (2017) found that 52.5 percent owned guns, and based on the survey results, estimated the gun

[4] Indeed, federal law makes it so. The Firearm Owners Protection Act of 1986 specifically prohibits government agencies from establishing a registry of gun ownership. As a consequence, Stephenson and Shorter (2021, p. 375) note, "researchers and policymakers do not know which individuals own guns, how many guns each individual owns, or how many guns are owned nationwide."

stock to be between 245 million and 285 million units.[5] Similarly, Berrigan, *et al*. (2022) obtained a 95 percent confidence interval for the gun stock that ranged widely from 257.8 million to 394.2 million firearms. Additionally, while surveys yield rich cross-sectional information, they tend to be conducted sporadically and thus do not provide a consistent time series.

An alternative approach uses data on manufacturing, importing, and exporting to estimate both the stock and flow of firearms over time (Azrael, *et al*., 2017; Mascia and Brownlee, 2025). The National Research Council (2005) used production data to estimate a stock of 258,322,465 guns in 1999. Taking that as an initial value, we sum each year's imports and domestically manufactured guns, and then subtract exports, as reported by the Bureau of Alcohol, Tobacco, Firearms, and Explosives (Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF), 2022); following accepted practice (Legault and Lizotte, 2009; Cook and Goss, 2014; Azrael, *et al*., 2017), we assume that one percent of the previous year's stock depreciates. The resulting estimates, in Table 1, show the stock of firearms increasing 54 percent between 1999 and 2020, from 258.32 million to 396.9 million.[6] By comparison, the population grew 17.5 percent, so the number of guns per capita rose from 0.925 to 1.197. Notice that the volume of guns

[5] Daruwala, *et al*. (2025) recently found that 26.66 percent of survey subjects reported owning firearms, and 61.35 percent reported that they did not own guns, but nearly 12 percent did not respond to the question about gun ownership. If non-responders are excluded, or equivalently, if the distribution of gun ownership among non-responders is identical to that of respondents, then the estimated ownership rate is 26.66/88.01, or 30.3 percent, but if all non-responders own guns, then the ownership rate exceeds 38 percent. Aside from non-responders, another problem is the potential for false negatives: Bond, *et al*. (2024) calculated that up to 45 percent of survey respondents who claim not to own firearms are likely to be gun owners in actuality. Legault (2013) attributes such under-reporting to differences between men and women in the willingness to admit gun ownership.

[6] Using such an approach, Legault and Lizotte (2009) estimated a stock of 216.7 million guns in 2006. Azrael, *et al*. (2017) estimated a stock of 272 million guns in 2013. The Small Arms Survey estimated that there were 393.3 million guns in the U.S. in 2017 (see https://www.smallarmssurvey.org/database/global-firearms-holdings). Mascia and Brownlee (2025) estimated a stock of 345.8 million for 2020. A trade association, the National Shooting Sports Foundation (NSSF) estimated a stock of 473.2 million guns for 2021 (https://www.nssf.org/articles/nssf-releases-most-recent-firearm-production-figures-2024/). While the precise values differ, our time series is highly consistent with those of Legault and Lizotte (2009), Azrael, *et al*. (2017), and Mascia and Brownlee (2025), with correlation coefficients of approximately 1. For the purposes below, changes in the stock matter more than the size of the stock.

manufactured and imported (net of exports) in 2020, which we take as our base year, was $Q_1 = 17{,}050{,}491$.

[Table 1 here]

Gun-Related Deaths

The final two columns of Table 1 provide the number of gun-related deaths (including homicides, suicides, and accidents) by year, as reported by the National Safety Council (2024), along with the population-adjusted firearm-related death rate.[7] Over the period, firearm-related deaths per million individuals increased 28.8 percent, from 105.89 in 1999 to 136.41 in 2020. And in 2020, there were 114 gun-related deaths for every million guns in the civilian arsenal.

Data on the number of nonfatal firearm-related injuries, by contrast, are notoriously unreliable. The Web-Based Injury Statistics Query and Reporting System (WISQARS), available from the Centers for Disease Control and Prevention (CDC), have been widely criticized for being based on relatively small samples of emergency room visits (Barber, 2021). An alternative data series, the National Emergency Department Survey (NEDS) from the Healthcare Cost and Utilization Project (HCUP) underwent a change in survey methodology in 2015, resulting in temporal inconsistency. Consequently, we focus on firearm-related deaths, recognizing this as a limitation that makes the estimates conservative.

Prices

Marifian and Becker (2020) collected the advertised retail prices of handguns and rifles in two publications during two different time periods: *Gun Digest* in 2016, and *Armslist* in August of

[7] Firearm-related deaths also include a small number of incidents involving law enforcement. Assuming that police only use deadly force when similarly threatened, such incidents presumably involve suspects who were armed.

2020. Similarly, Moshary, *et al*. (2022) obtained prices from the *Gallery of Guns* website for handguns in October and November of 2020 and for long guns between March and May of 2021. The sample sizes, means, and standard deviations from both studies are reported in Table 2. Because the data were collected at different times, we convert all monetary values into November 2020 dollars, using the Producer Price Index (PPI) for small arms.[8] The PPI weights used as inflation and deflation factors are shown in the table, as are the resulting sample means and standard deviations.

[Table 2 here]

We pool the summary statistics from the top panel of Table 2 in a simple meta-analysis to determine the mean handgun price, and pool the statistics from the final four rows to obtain a mean price for long guns. From the combined sample of 48,746 handguns, we find a mean price (in 2020 dollars) of $788.35 and a standard error of $2.06, for a 95 percent confidence interval ranging narrowly from $784.32 to $792.38. From the combined sample of 121,664 long guns, we find a mean price of $1,352.85 and a standard error of $2.26, for a 95 percent confidence interval that ranges from $1,348.42 to $1,357.28. While the mean prices for each type of firearm appear to be reasonably accurate and lie within narrow confidence intervals, long guns account for more than 70 percent of the data, and were clearly over-sampled relative to handguns in the primary studies. We therefore weight the handgun and long gun means by the proportions of each type of firearm in national sales during 2020. Pistols and revolvers accounted for 36 percent, and long guns accounted for 31 percent of FAET revenues in 2020, with ammunition accounting for the remaining 33 percent (Gravelle, 2023; U.S. Department of the Treasury,

[8] The PPI is available at the Bureau of Labor Statistics website, https://data.bls.gov/cgi-bin/srgate#. We treat the October-November 2020 data as having been collected in November, the March to May 2021 period as April 2021, and the 2016 data as having been collected at mid-year (July 1).

2024). Because handguns are taxed at 10 percent while long guns are taxed at 11 percent, and handgun prices are only 58 percent of long gun prices on average, we estimate that handguns accounted for 68.7 percent of firearm sales, and long guns accounted for 31.3 percent.[9] Thus, the overall weighted average price of a firearm in 2020 is estimated at $965.19 before taxes; we take this as P_1^S or equivalently, MPC_1.

Taxes and Elasticities

Given the proportions of handgun and long gun sales calculated above, the weighted average federal tax rate on firearms in 2020 was $(10 \times 0.687) + (11 \times 0.313) = 10.31$ percent. The average rate of state and local general sales taxes was 6.56 percent (Fritts, 2020). The combined tax rate on firearms across the country therefore averaged 16.87 percent, implying that while sellers received $965.19 per gun, buyers paid an average price of about $1,128.02, of which about $162.83 represented the combined federal, state, and local tax revenue per gun. Thus we have $\tau_1 = 0.1687$ and $P_1^D = 1{,}128.02$.

This, of course, does not imply that buyers bear the entire tax burden. As noted above, the economic incidence depends on the price elasticities of supply and demand, of which there have been very few studies. Recently however, McDougal, *et al*. (2023) applied instrumental variables to time series data spanning the seven decades from 1946 to 2016 and obtained price elasticities of supply and demand equal to $\varepsilon^S = 3.239$ and $\varepsilon^D = -2.561$, respectively. With

[9] To see this, let sales revenue from handguns be $P_{HG}Q_{HG} = 0.36FAET/0.10$ and let sales revenue from long guns be $P_{LG}Q_{LG} = 0.31FAET/0.11$ where P is price, Q is quantity, and $FAET$ denotes FAET revenue. Then $P_{HG}Q_{HG}/P_{LG}Q_{LG} = 1.2774$ and dividing this by $P_{HG}/P_{LG} = 788.35/1{,}352.85 = 0.58273$ yields $Q_{HG}/Q_{LG} = 2.1921$, from which $Q_{HG}/(Q_{LG} + Q_{HG}) = 0.68673$ and $Q_{LG}/(Q_{LG} + Q_{HG}) = 0.31327$. As a confirmatory analysis, we compared the number of background checks conducted for the two categories of firearms in 2020. Data from the National Instant Criminal Background Check (NICS) system (https://www.nicsezcheckfbi.gov/) indicate that handguns accounted for more than 62.5 percent, and long guns accounted for less than 37.5 percent of background checks. Because some background checks result in applications being denied, we take the proportions calculated from the tax revenue data as being more representative of the actual sales proportions.

these elasticities, $\alpha = 0.39047$, $\gamma = 0.308737$, buyers pay 55.845 percent of the taxes on guns, and sellers pay 44.155 percent.[10] And using the elasticities in equation (9) gives the equilibrium output as $Q_0 = 21{,}309{,}087$ or about 21.31 million units, while (10) gives the equilibrium price, in the absence of any taxes, as $P_0 = \$1{,}033.97$.[11]

Marginal External Cost and Deadweight Loss

In a seminal study, Cook and Ludwig (2006) estimated the marginal external cost imposed on society by each additional gun-owning household as $(e \times h \times n/g)VSL$, where e denotes the elasticity of the homicide rate with respect to the prevalence of guns (or more precisely, gun-owning households), h refers to the per capita homicide rate, n is the number of persons per household, g is the prevalence of gun ownership among households, and VSL is the value of a statistical life. This expression can be rewritten as

$$(e \times h \times n/g)VSL = \left[\frac{\left(\frac{\partial HOM}{HOM}/\frac{\partial GOH}{GOH}\right)\left(\frac{HOM}{POP}\right)\left(\frac{POP}{HH}\right)}{\left(\frac{GOH}{HH}\right)}\right]VSL$$

where HOM denotes homicides, GOH denotes gun-owning households, POP denotes the population, and HH denotes the number of households. Mathematically, the expression reduces to $(\partial HOM/\partial GOH)VSL$; that is, the change in the number of homicides, divided by the change in the number of gun-owning households, monetized by the value of a statistical life. Cook and Ludwig (2006) applied data from the 200 most populous counties in the country from 1980 to 1999, and using initial parameter values of $h = 10/100{,}000$, $n = 2$, $g = 0.2$, $e = 0.1$, and

[10] Other price elasticity estimates obtained by McDougal, *et al*. (2023), using more limited sets of controls, yield similar incidence rates. Estimates that used only sociodemographic controls suggest that buyers pay 53 percent, and estimates using only economic controls imply that buyers pay 49 percent of any tax on guns. Earlier studies of price elasticities examined only selected types of weapons and/or investigated only the demand side of the market (Bice and Hemley, 2002; Bartley and Williams, 2021).

[11] These further imply, from (11) and (12), $a = 751{,}813$ and $b = 5.648$.

$VSL = \$1$ million, they estimated a lower bound of $100. On that basis, they suggested that on average, "the appropriate license fee for a [gun-owning] household would be $100 per year" (Cook and Ludwig, 2006, p, 389), but explained that the fee would increase with the local homicide rate (h) and decrease with the prevalence of gun-owning households in a locality (g). After correcting for measurement error, their results suggested an elasticity closer to $e = 0.3$, implying a license fee of $300 per gun-owning household per year. Adding in the costs of nonfatal gun-related injuries raised the estimate to $600 (if e = 0.1) or $1,800 (if e = 0.3) per year, and led to their conclusion that "the average annual marginal social cost of household gun ownership is in the range of $100 to $1800" (Cook and Ludwig, 2006, p. 379).

While Cook and Ludwig (2006) introduced an innovative model, the annual license fee they describe is fundamentally different from a Pigouvian excise tax. First, such a fee would apply to any household that owned a gun, rather than to the purchase of a gun, and as Cook and Ludwig (2006) acknowledged, the prevalence of gun-owning households is not the same as the prevalence of guns, because most households that own a gun actually own several of them.[12] Moreover, as a matter of implementation, collecting the annual fee would require knowing exactly which households own guns each year. In practice, however, we do not even know the precise fraction of households that own firearms, let alone which particular households own them.[13] Finally, flat fees lose value over time due to inflation; in the two decades following the

[12] Berrigan, *et al*. (2022) estimated that gun owners own an average of five guns each.

[13] Similar to the studies of individual gun ownership discussed above, household ownership rates are based on surveys of relatively few respondents. From their National Firearm Survey of 3,949 individuals, for example, Hepburn, *et al*. (2007) estimated that 38 percent of households owned guns in 2004; for the same year, the General Social Survey sampled only 876 individuals and estimated that 34.7 percent of households owned guns (Smith and Son, 2015). Cook and Ludwig (2006) used an estimated proportion of households owning handguns as the basis for setting $g = 0.2$. Indeed, because reliable data on firearm prevalence are elusive, they estimated the elasticity of homicides with respect to the proportion of households owning guns by using a proxy: the ratio of firearm-related suicides to all suicides (FSS). Because suicides are relatively uncommon in the general population, FSS tends to exhibit instability, especially when measured at the county level (Cook and Ludwig, 2019; Haviland, *et al*., 2021). Siegel, *et al*. (2013) subsequently replicated the elasticity analysis for the 30-year period from 1980 through 2010,

Cook and Ludwig (2006) study, fixed dollar values declined more than 33 percent.[14] Thus, a flat license fee would fail to keep pace with inflationary or other increases in external costs.

By contrast, as indicated in Figure 1, an *ad valorem* Pigouvian tax is levied on current market transactions—that is, the flow of output, rather than the stock. We therefore seek the marginal external cost of each gun added to the existing stock. To that end, we estimate

$$MEC_1 = (\partial Gun\ Deaths/\partial Gun\ Stock)VSL\ . \tag{19}$$

In comparison to Cook and Ludwig (2006), this narrows the focus from all homicides to those committed with firearms, yet simultaneously broadens the focus to include suicides, accidents, and other deaths that are attributable to firearms.

To measure $\partial Gun\ Deaths/\partial Gun\ Stock$, we utilize the aggregate time series data in Table 1. To control for population changes over time, our dependent variable is the firearm-related death rate (*DR*) per million persons, taken from the final column of Table 1; that is, $DR = Gun\ Deaths/(POP/1{,}000{,}000)$. The main independent variable is the gun stock (*GS*) measured in millions of units: $GS = Gun\ Stock/1{,}000{,}000$. Then the fundamental regression equation is simply

$$DR = \beta_0 + \beta_1 GS + \sum_{i=2}^{k} \beta_i X_i \tag{20}$$

where each X_i denotes a control variable. From (20), $\beta_1 = \partial DR/\partial GS$, and multiplying by the population (in millions) recovers $\partial GD/\partial GS$ per million guns; then multiplying by the *VSL* in millions of dollars generates the marginal external cost per gun as in (19).

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and found an elasticity of gun-related homicides with respect to FSS equal to approximately 0.9, three times larger than the Cook and Ludwig (2006) estimate. More recently, Chalak, *et al*. (2022) estimated elasticity values ranging from 0.359 up to 1.011 for the years 1980 through 2014. Kim and Wilbur (2022) found a negative effect of FSS on homicides, and concluded that FSS is a valid proxy only for cross-sectional, not cross-temporal, analysis.

[14] From 2000 to 2020, the Consumer Price Index (CPI) rose by slightly more than 50 percent, from 172.2 to 258.8 (https://data.bls.gov/timeseries/CUUR0000SA0?amp%253bdata_tool=XGtable&output_view=data&include_graphs=true).

Unfortunately, the limited size of the data set permits only a few additional control variables. We use the average annual unemployment rate published by the Bureau of Labor Statistics as a control for the state of the economy.[15] Because mental illness has often been considered a contributing factor to gun violence (Bleyer, *et al*., 2024), we also control for depression and alcohol abuse using data from the Institute for Health Metrics and Evaluation.[16] Both depression and alcohol use disorder are measured in cases per 100,000 individuals. Summary statistics for all variables are given in Table 3.

[Table 3 here]

The basic results from ordinary least squares regressions are shown in Table 4. To check robustness, we ran multiple iterations.[17] Alcohol abuse consistently has an unexpected negative sign, but is never statistically significant. Unemployment, in both current and lagged form, exerts a negative effect on the death rate. In each iteration, the coefficients of the gun stock (either current or lagged) and depression are both positive and statistically significant well below the one percent level, suggesting that both firearm availability and depression contribute to gun violence. Where *GS* is measured in natural log form, we divide $\hat{\beta}_1$ by the average gun stock in millions, and where *DR* is estimated in log form we multiply $\hat{\beta}_1$ by the average death rate to get $\partial DR/\partial GS$. In every case, we multiply $\partial DR/\partial GS$ by the 2020 population in millions (331.526933) to recover $\partial GD/\partial GS$ per million, which is shown in the final column. The results lie in a fairly narrow range from 54.6 to 65.5, so we take 60 to be an approximately typical

[15] The annual unemployment rates can be found at the Bureau of Labor Statistics website, https://data.bls.gov/timeseries/LNU04000000?periods=Annual+Data&periods_option=specific_periods&years_option=all_years.

[16] These data are available from https://www.healthdata.org/.

[17] In each case, this simple model explains at least 93 percent of the variation in gun-related deaths. Tests for serial correlation were mostly indeterminate, though in several of the regressions, the Durbin-Watson test rejected serial correlation. Although the gun stock increased monotonically over the period, neither the death rate nor any of the control variables did so.

outcome, indicating that for every one million guns added to the existing gun stock through domestic sales and net imports, there are about 60 additional gun-related deaths. This marginal rate is about half of the average rate calculated above.

[Table 4 here]

In stark contrast to the sparse literature on the price elasticities of firearms, there is a vast body of research on the value of a statistical life, which includes primary studies (Sweis, 2022), reviews of the literature (Robinson and Hammitt, 2016), meta-analyses (Viscusi, 2018), and even a meta-analysis of meta-analyses (Banzhaf, 2022). Not surprisingly, the estimates of VSL vary considerably. The U.S. Department of Health and Human Services (HHS, 2021), for example, estimated VSL in 2020 dollars to lie between $5.3 million and $17.4 million, with a central estimate of $11.4 million. Other recent values are shown in Table 5, along with the base years in which monetary values were reported and the inflation factors based on the average Consumer Price Index (CPI) for those years; the fifth column converts the values to 2020 dollars for consistency with Table 2. The wide variation in samples and methodologies make any comparison of these studies difficult, but there is a clustering of central values that includes $7.2 million (Sweis, 2022), $8.06 million (Banzhaf, 2022), $8.8 million (Viscusi, 2018) and $8.99 million (Banzhaf, 2022); our analysis focuses on these four estimates, and treats the others as outliers. Among all such studies, the most comprehensive is arguably that of Banzhaf (2022), which incorporates results from 267 primary studies.[18]

[Table 5 here]

[18] Two decades ago, Cook and Ludwig (2006) noted that VSL had generally been estimated to range between $3 million and $9 million in the U.S. They used a lower value, $1 million, to monetize homicides, arguing that many murder victims were criminals who inherently accepted a high risk of death. The more recent phenomenon of mass shootings suggests that homicide victims are more randomly selected, and our inclusion of suicides further justifies the higher VSL values for measuring the external cost to society.

Following equation (19), the sixth column of Table 5 multiplies the VSL in 2020 dollars from the various studies by our estimate of 60 gun-related fatalities per million guns added to the stock, to generate MEC_1; the central values range from $432 to about $540. Following (13), these values are used with our estimate of MPC_1 to obtain estimates of λ ranging from 1.45 to 1.56, and MSC_1 ranging from about $1,400 to $1,500. As a conservative example, using the $7.2 million VSL from Sweis (2022), $MEC_1/MPC_1 = 432/965.19 = 0.4476$, so $\lambda = 1.4476$ and $MSC_1 = \$1{,}397.19$. From (14), this implies that Q_2 would be about 12.555 million units, and from (15), this implies a deadweight loss at equilibrium of $2.212 billion. But the deadweight loss at present (from (16)) is $637.8 million, so roughly $1.574 billion is eroded by existing federal, state, and local taxes. In this case, (17) indicates that a Pigouvian tax rate of 44.76 percent would eliminate the deadweight loss entirely.

Among the central estimates, these results imply a deadweight loss at equilibrium ranging from $2.21 billion to $3.21 billion; but existing taxes have already eliminated about two-thirds of this, so the remaining deadweight loss is estimated to range from $638 million to $1.162 billion. The Pigouvian tax rates range from 44.76 percent at the lower end of the central range, up to 56 percent.[19] Across all estimations, the tax rate ranges from 32.7 percent to 77.25 percent.

While Pigouvian taxes are based on the marginal external cost of an additional unit of output, we can also estimate the total external cost (TEC) of the stock of guns, conservatively, as the product of gun-related deaths and VSL. The eleventh column of Table 5 provides these estimates in billions of 2020 dollars. Our central estimates range from $325.6 billion to $406.5 billion, while the full set ranges from about $238 billion to $562 billion, broadly consistent with

[19] Using the price elasticities of $\varepsilon^S = 3.239$ and $\varepsilon^D = -2.561$ estimated by McDougal, *et al*. (2023), Eisenhauer (2025c) found that gun buyers and sellers would tolerate taxes of at least 67 percent or more without moving their transactions to the black market. With the same elasticities, Eisenhauer (2025b) found that by reducing gun sales, tax rates between 46.3 and 56.9 percent could decrease gun-related homicides by 13.4 to 14.8 percent.

the prior estimates noted above. With an estimated stock of 397 million guns, the average external cost per firearm ranges from $600 to $1,416, with central estimates between $820 and $1,024 per unit. Thus, the average social cost per firearm is between $1,785 and $1,989, or roughly twice the average price.

Finally, the twelfth column of Table 5 shows the tax revenue that would be generated by the tax rates in the tenth column. Our central estimates range narrowly from about $4.935 billion to $5.364 billion. Assuming that state and local taxes remained 6.56 percent on average, state and local governments would collect a fraction of the tax revenue, equal to $0.0656/\tau_2$, while the rest accrued to the federal government. For example, if the federal government increased its excise tax to 43.53 percent to reach the Pigouvian rate of 50.09 percent, then state and local governments would receive 13.1 percent of $5.161 billion, or $676 million, while $4.485 billion would accrue to the federal government.[20]

Suicides

To the extent that suicide represents a self-inflicted harm, one may question whether suicide constitutes a true externality. If suicides, which account for roughly 54 percent of gun-related fatalities (National Safety Council, 2024), are excluded from social costs and our estimates of MEC_1 are reduced proportionately, then the Pigouvian tax rates would also decline; at the low end of the estimates, this would imply that current taxes are roughly sufficient to internalize negative externalities. There are, however, several important reasons for including suicides among the social costs. First, suicide imposes unexpected financial and emotional losses on

[20] Because both $Q_2 < Q_1$ and $P_2^S < P_1^S$, if states and localities held their tax rates constant while the federal government raised its rate, states and localities would collect less tax revenue at Q_2 than they currently collect at Q_1. By contrast, if states or localities raise taxes or establish new taxes on firearms but the federal government does not, then states and localities will gain while federal FAET revenues decline (Eisenhauer, 2025d).

families, friends, and employers; indeed, foregone future earnings are an important component in the calculation of *VSL* (Johansson, 2007). Second, the firearm may not be in the possession of its original buyer or true owner at the time of the suicide; guns often change hands through theft, borrowing, straw purchases, and other informal or illegal diversions (Miller, *et al.*, 2022). This is especially true among youths who commit suicide by firearm, roughly two-thirds of whom use someone else's weapon (Choi, *et al*., 2017). Third, if the buyer of the gun was not planning to commit suicide at the time of the purchase, but was subsequently motivated to do so by the convenience of the weapon, then the original transaction ultimately resulted in an unintended consequence (Vitt, *et al*., 2018; Sarai, *et al*., 2017; Balestra, 2018). And fourth, the inclusion of suicides may compensate for the exclusion of nonfatal shooting injuries, robberies, and other externalities associated with firearms; the estimates above are conservative, insofar as they include only deaths.[21]

IV. Conclusion

Remarkably few studies have attempted to quantify either the marginal social cost or the marginal external cost of gun violence, the deadweight losses they create, or the Pigouvian tax rates that would induce efficiency in the market. The present study indicates that fully internalizing negative externalities would require gun taxes of at least 45 percent, with higher estimates closer to 56 percent or more. These are well above the existing tax rates that apply to guns, as well as recent legislative proposals to raise them. Indeed, even at the low end, such taxes would exceed those on most other goods that generate negative externalities, such as tobacco or alcohol (Eisenhauer, 2024).

[21] Song, *et al*. (2022) recently estimated that nonfatal firearm injuries cost about $30,000 per victim annually.

Certainly, the external costs associated with both deliberate and accidental shootings result from the use of both new and extant guns. From a policy perspective, there is little that can be done about the existing stock of firearms in civilian possession; the absence of a comprehensive federal registry of gun ownership means that neither researchers nor policymakers know exactly who owns a gun, or how many firearms each gun owner possesses (Stephenson and Shorter, 2021). There are, however, data reported by the ATF on additions to the stock of guns through manufacturing and imports, and our analysis uses those data to estimate the marginal external cost. Regardless of whether the resulting tax would be levied on the manufacture and importation of firearms or on their purchase, the economic incidence would depend upon the market structure and price elasticities. As noted above, recent empirical estimates indicate that sellers pass about 56 percent of a gun tax through to buyers.

An important caveat is that this analysis takes preferences as fixed, but this assumption may not hold (Chan, 2024). Kremer and Willis (2016) point out that the announcement of a Pigouvian tax on durables may cause an immediate rush to purchase before the tax takes effect. In contrast, Lucas (2024) suggests that Pigouvian taxation may diminish preferences for the taxed products, and Huang and Xiao (2021) suggest that voters who support Pigouvian taxes may persuade others to accept them as well. If preferences are malleable in these ways, then Pigouvian taxes may have even larger impacts on firearm sales, in which case lower tax rates than those estimated here could potentially eliminate the deadweight loss.[22]

Although we have utilized the best available data, the empirical results are subject to the limitations on the comprehensiveness and quality of the data set, and ultimately represent an

[22] While not strictly Pigouvian in nature, the recent excise taxes on firearms adopted in California and Colorado may serve as test cases to indicate whether preferences change, and if so, in which direction, after the announcement of a tax.

embryonic evaluation of social policy. Future replications would benefit from further refinements such as a longer time series and the inclusion of nonfatal shootings, armed robberies, and other costs, and additional control variables, including better controls for the economy and mental health. As noted above, there is also limited information on the price elasticities of firearm supply and demand, and further confirmation of these parameters would be valuable. Nonetheless, this initial analysis highlights the failure of existing tax rates to fully induce internalization of the negative externalities associated with firearms.

Finally, while we have conducted this study for the U.S., where gun-related violence is most pronounced (Grinshteyn and Hemenway, 2019), the methodology could readily be applied to other countries where suitable data are available.

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Figure 1. Pigouvian Taxation with Negative Externalities

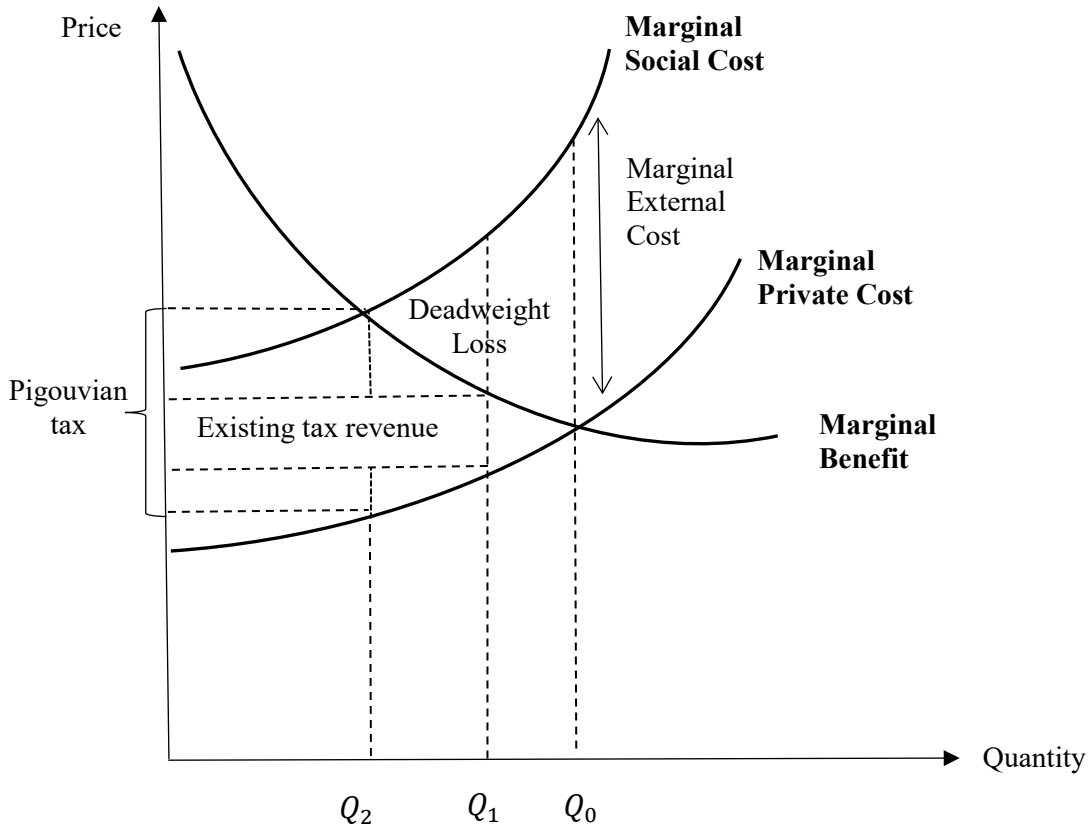


Table 1. U.S. Gun Stock, Gun-Related Deaths, and Population

Year	Manufactured	Exported	Imported	Gun Stock	Population	Deaths	Death Rate per Million
1999				258,322,465	272,690,813	28,874	105.89
2000	3,932,734	191,067	1,401,298	260,882,205	282,162,411	28,663	101.58
2001	3,093,399	195,272	1,492,039	262,663,549	284,968,955	29,573	103.78
2002	3,454,556	181,934	2,265,274	265,574,810	287,625,193	30,242	105.14
2003	3,438,035	165,611	2,015,468	268,206,954	290,107,933	30,136	103.88
2004	3,381,633	159,760	2,065,787	270,812,544	292,805,298	29,569	100.99
2005	3,355,951	209,056	2,140,273	273,391,587	295,516,599	30,694	103.87
2006	3,792,516	381,949	2,486,356	276,554,594	298,379,912	30,896	103.55
2007	4,109,231	216,329	2,979,593	280,661,543	301,231,207	31,224	103.65
2008	4,534,323	290,968	2,646,392	284,744,674	304,093,966	31,593	103.89
2009	5,787,834	228,131	3,663,462	291,120,393	306,771,529	31,347	102.18
2010	5,559,771	264,936	2,840,616	296,344,640	309,327,143	31,672	102.39
2011	6,731,958	333,163	3,035,236	302,815,224	311,583,481	32,351	103.83
2012	8,817,423	344,538	4,571,157	312,831,114	313,877,662	33,563	106.93
2013	11,155,332	504,628	5,542,588	325,896,095	316,059,947	33,635	106.42
2014	9,332,212	590,939	3,628,163	335,006,570	318,386,329	33,594	105.51
2015	9,642,367	400,684	3,930,450	344,828,637	320,738,994	36,247	113.01
2016	11,857,276	453,263	5,127,603	357,911,967	323,071,755	38,658	119.66
2017	9,004,451	620,237	4,487,129	367,204,190	325,122,128	39,773	122.33
2018	9,165,323	621,256	4,306,207	376,382,422	326,838,199	39,740	121.59
2019	7,537,714	447,761	3,988,782	383,697,333	328,329,953	39,707	120.94
2020	11,302,827	650,485	6,398,149	396,910,851	331,526,933	45,222	136.41
Mean	6,618,422	354,856	3,381,525	308,762,016	306,418,925	33,499	108.97

Sources: National Research Council (2005), Bureau of Alcohol, Tobacco, Firearms and Explosives (2022), https://usafacts.org/data/topics/people-society/population-and-demographics/population-data/population/, and https://injuryfacts.nsc.org/home-and-community/safety-topics/guns/data-details/.

Table 2. Firearm Prices

Study	Gun Type	Source	Sample Dates	Sample Size	Mean ($)	SD ($)	PPI Wt.	Mean 2020 ($)	SD 2020 ($)
Marifian & Becker (2020)	Handgun	*Armslist*	Aug. 2020	33,362	657	381	1.032	678.26	393.33
	Handgun	*Gun Digest*	2016	1,882	602	615	1.086	653.85	667.97
Moshary *et al*. (2022)	Pistol	*Gallery of Guns*	Nov. 2020	8,724	1,307	306	1.000	1,307.00	306.00
	Revolver	*Gallery of Guns*	Nov. 2020	4,778	663	279	1.000	663.00	279.00
Marifian & Becker (2020)	Rifle	*Armslist*	Aug. 2020	14,455	776	568	1.032	801.11	586.38
	Rifle	*Gun Digest*	2016	2,605	712	2,683	1.086	773.33	2,914.10
Moshary et al. (2022)	Rifle	*Gallery of Guns*	Mar/May 2021	80,863	1,661	584	0.963	1,600.56	562.75
	Shotgun	*Gallery of Guns*	Mar/May 2021	23,742	943	598	0.963	908.68	576.24

Table 3. Summary Statistics

Variable	Minimum	Maximum	Mean	Std. Dev.
Death rate per million individuals (DR)	100.99	136.41	108.97	9.28
Gun stock in millions (GS)	258.32	396.91	308.76	44.80
Unemployment rate (annual average)	0.037	0.096	0.059	0.018
Depression (cases per 100,000 individuals)	4,776.68	5,764.79	4,896.04	201.57
Alcohol use disorder (cases per 100,000 individuals)	2,337.77	2,427.47	2,401.28	29.40

Table 4. Regression Results

Dependent Variable: Death Rate (DR)									
Constant	**GS**	**Lagged GS**	**Ln(GS)**	**Unemployment**	**Lagged Unemployment**	**Depression**	**Alcohol Use Disorder**	R^2	**Implied $\partial GD/\partial GS$ per million**
68.105 (80.762)	0.179*** (0.015)			-89.875** (37.090)		0.014*** (0.004)	-0.033 (0.029)	.945	59.37
101.874 (68.419)	0.182*** (0.014)				-98.595** (35.064)	0.009*** (0.003)	-0.037 (00.236)	.950	60.30
7.585 (14.005)	0.171*** (0.012)				-124.757*** (30.515)	0.011*** (0.013)		.944	56.79
46.389 (82.556)		0.196*** (0.016)		-75.223* (37.124)		0.014*** (0.004)	-0.026 (0.030)	.949	64.82
-23.801* (12.676)		0.188*** (0.013)		-93.952*** (29.844)		0.017*** (0.003)		.947	65.50
67.333 (70.961)		0.198*** (0.015)			-85.998** (34.847)	0.010*** (0.003)	-0.026 (0.027)	.954	63.15
0.365 (13.467)		0.190*** (0.013)			-103.576*** (29.598)	0.012*** (0.003)		.951	62.31
-194.990** (73.097)			57.036*** (4.925)	-101.083** (38.070)		0.015*** (0.004)	-0.038 (0.031)	.941	61.24
-161.017** (62.215)			58.124*** (4.529)		-110.504*** (35.849)	0.010*** (0.003)	-0.043 (0.027)	.947	62.41
-252.070*** (24.647)			54.094*** (3.898)		-140.016*** (31.871)	0.012*** (0.003)		.939	58.08
Dependent Variable: Ln(DR)									
Constant	**GS**	**Lagged GS**	**Ln(GS)**	**Unemployment**	**Lagged Unemployment**	**Depression**	**Alcohol Use Disorder**	R^2	**Implied $\partial GD/\partial GS$ per million**
4.462*** (0.720)	0.001586*** (0.00013)			-0.798** (0.330)		0.000107*** (0.00003)	-0.00031 (0.00026)	.942	57.30

4.773*** (0.614)	0.001612*** (0.00012)				-0.862** (0.315)	6.287E-5** (0.000027)	-0.00035 (0.00023)	.946	58.26
3.875*** (0.127)	0.001512*** (0.000106)				-1.111*** (0.276)	8.372E-5*** (0.000025)		.939	54.61
4.254*** (0.735)		0.001732*** (0.00014)		-0.668* (0.331)		0.000108*** (.000035)	-0.000241 (0.00027)	.947	62.56
4.451*** (0.636)		0.001751*** (0.00013)			-0.751** (0.312)	7.118E-5** (0.00028)	-0.000249 (0.00024)	.951	63.27
3.810*** (0.121)		0.001684*** (0.00011)			-0.920*** (0.266)	8.565E-5*** (0.000024)		.948	60.83
2.132*** (0.650)			0.505*** (0.044)	-0.897** (0.338)		0.000117*** (0.000036)	-0.000357 (0.00027)	.938	59.12
2.443*** (0.557)			0.515*** (0.041)		-0.967*** (0.321)	6.687E-5** (0.000029)	-0.000407 (0.00024)	.943	60.30
1.584*** (0.222)			0.477*** (0.035)		-1.246*** (0.287)	9.066E-5*** (0.000026)		.934	55.85

Notes: GS = gun stock in millions. Standard errors are in parentheses; *, **, and *** indicate significance at the 10, 5, and 1 percent levels, respectively.

Table 5. Value of a Statistical Life, Marginal External Cost, and Pigouvian Tax Rates

Study	Base Year	VSL ($ mil)	CPI Wt.	VSL 2020 ($ mil)	MEC_1 ($)	MSC_1 ($)	DWL_0 ($ mil)	DWL_1 ($ mil)	Tax Rate (%)	TEC ($ bil)	Tax Rev ($ bil)
Hugonnier *et al*. (2022)	2017	4.9804	1.056	5.259	315.51	1,280.70	1283.3	223.1	32.69	237.8	4.242
Sweis (2022)	2020	7.2000	1.000	7.200	432.00	1,397.19	2212.1	637.8	44.76	325.6	4.935
Banzhaf (2022)	2019	7.9600	1.012	8.058	483.49	1,448.68	2675.8	874.2	50.09	364.4	5.161
Viscusi (2018)	2015	8.0720	1.092	8.814	528.85	1,494.04	3107.6	1105.7	54.79	398.6	5.329
Banzhaf (2022)	2019	8.8800	1.012	8.990	539.37	1,504.56	3210.6	1162.3	55.88	406.5	5.364
Kniesner & Viscusi (2024)	2022	12.0000	0.884	10.612	636.74	1,601.93	4211.2	1733.1	65.97	479.9	5.631
HHS (2021)	2020	11.4000	1.000	11.400	684.00	1,649.19	4724.8	2038.1	70.87	515.5	5.728
Viscusi (2018)	2015	11.3800	1.092	12.426	745.58	1,710.77	5418.2	2459.6	77.25	561.9	5.830

Notes: VSL = value of a statistical life; CPI = consumer price index; MEC = marginal external cost; MSC = marginal social cost; DWL = deadweight loss; TEC = total external cost; Tax Rev = tax revenue.